Material Flow Management: Examples from Germany

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Institute for Applied Material Flow Management
Taipei, 10.11.2008

Don´t waste your waste – turn it into ressources!

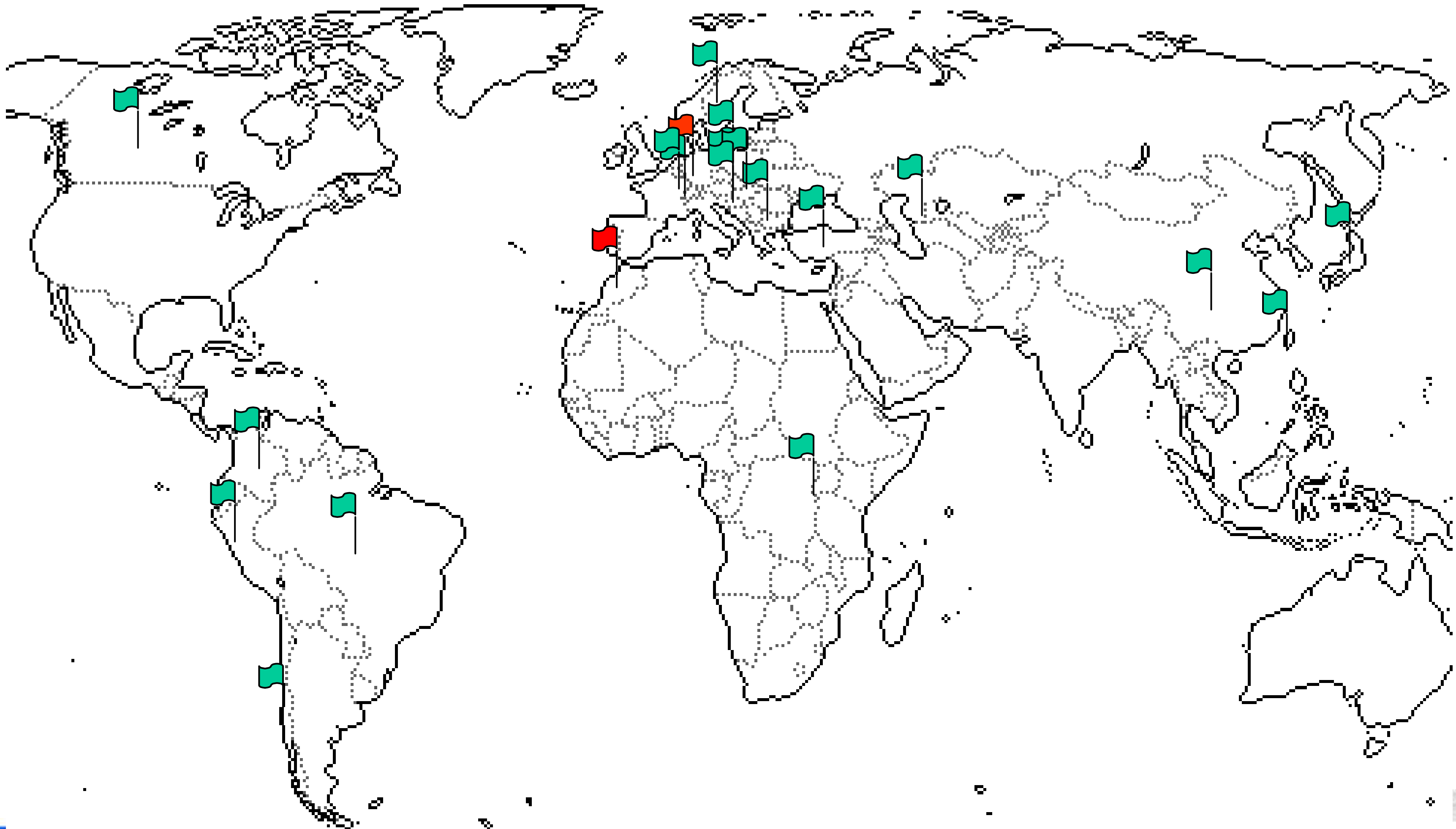
Content

- Zero Emission Campus Birkenfeld and IFAS
- Circular Economy and Material Flow Management
- Waste Management (example China, Germany)
- Waste Water Management
- Energy (Zero Emission Villages)
- Financing Material Flow Management
- Conclusion

Facts and Figures

- more than 6.000 students in 2005
  3.900 in Trier,
  2.030 in Birkenfeld
  100 in Idar-Oberstein
- more than 150 professors (51 at ECB)
- more than 10% international students from more than 60 countries
- more than 150 international university cooperation
- more than 10 research institutes
- more than 3 million € research budget per year (1.0 Mio € by IfaS)

IfaS Projects and network partner in 21 countries



Aerial View of the Past

US Military Hospital in Birkenfeld from 1953 until 1994

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ECB Aerial View

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Environmental- Campus Birkenfeld

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...More than just an university

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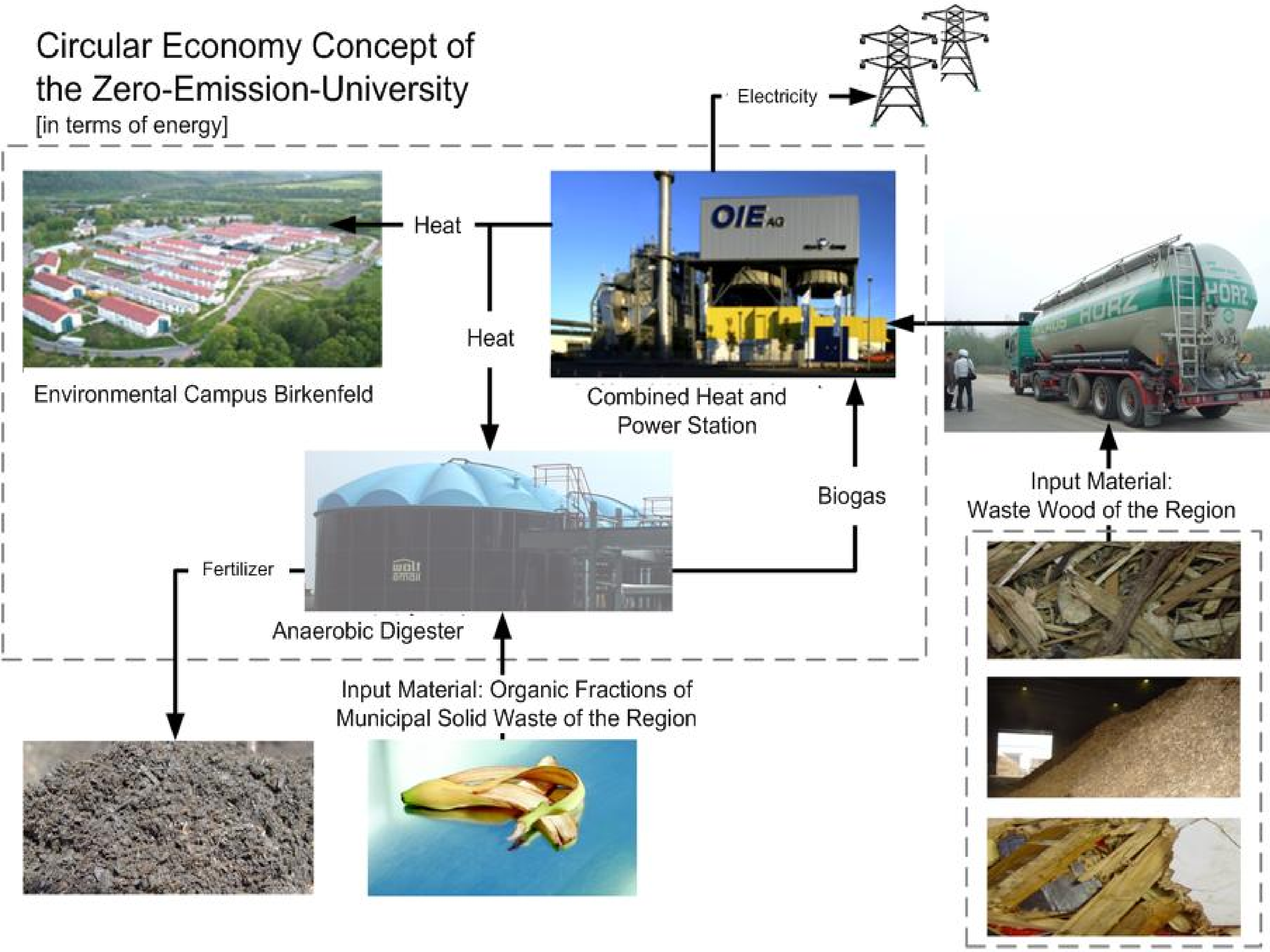
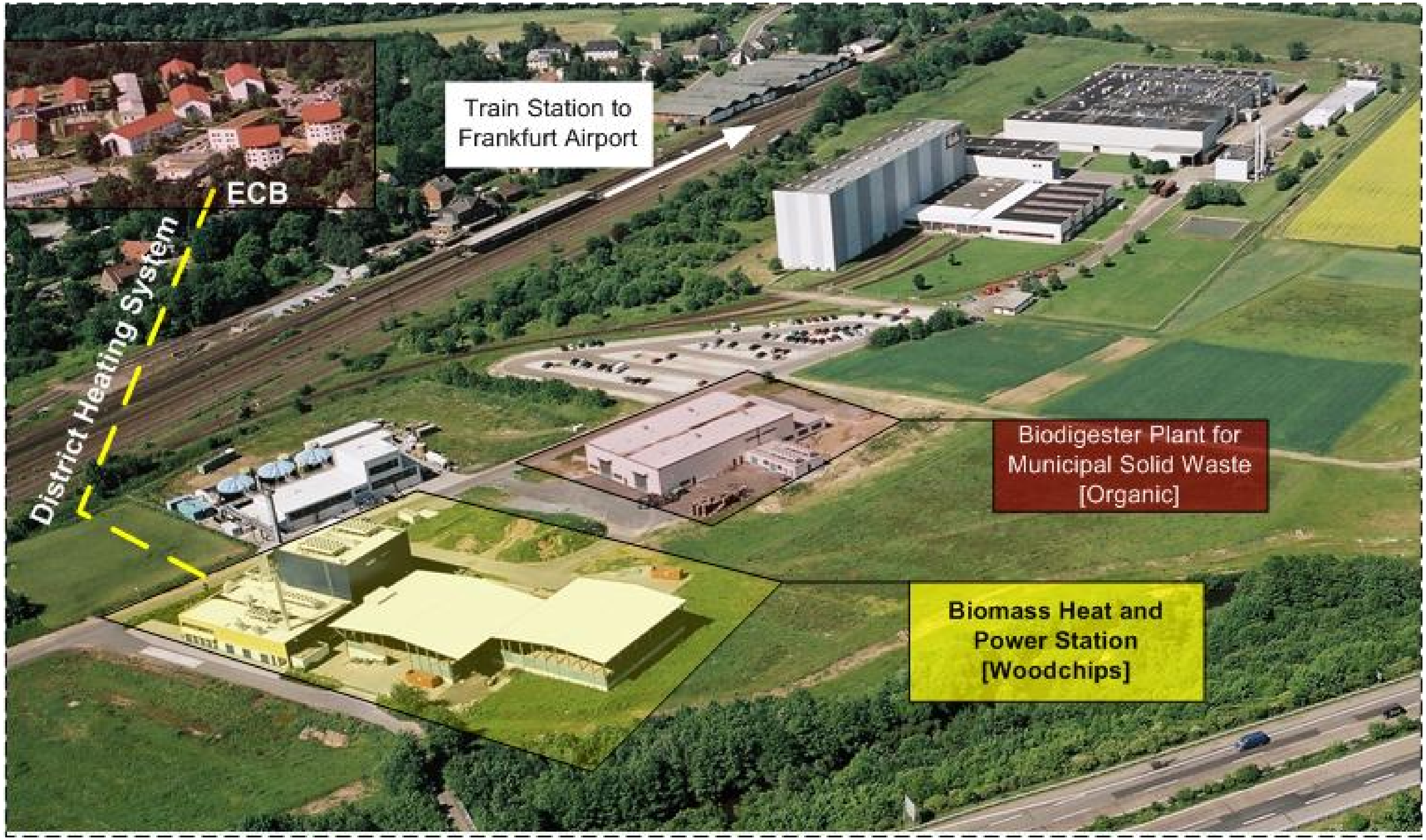


Circular Economy Concept of
the Zero-Emission-University
[in terms of energy]
Electricity
Heat
Heat
Environmental Campus Birkenfeld
OIE AG
Combined Heat and
Power Station
Biogas
Input Material:
Waste Wood of the Region
Fertilizer
Anaerobic Digester
Input Material: Organic Fractions of
Municipal Solid Waste of the Region

Neighbouring Eco-Industrial Park



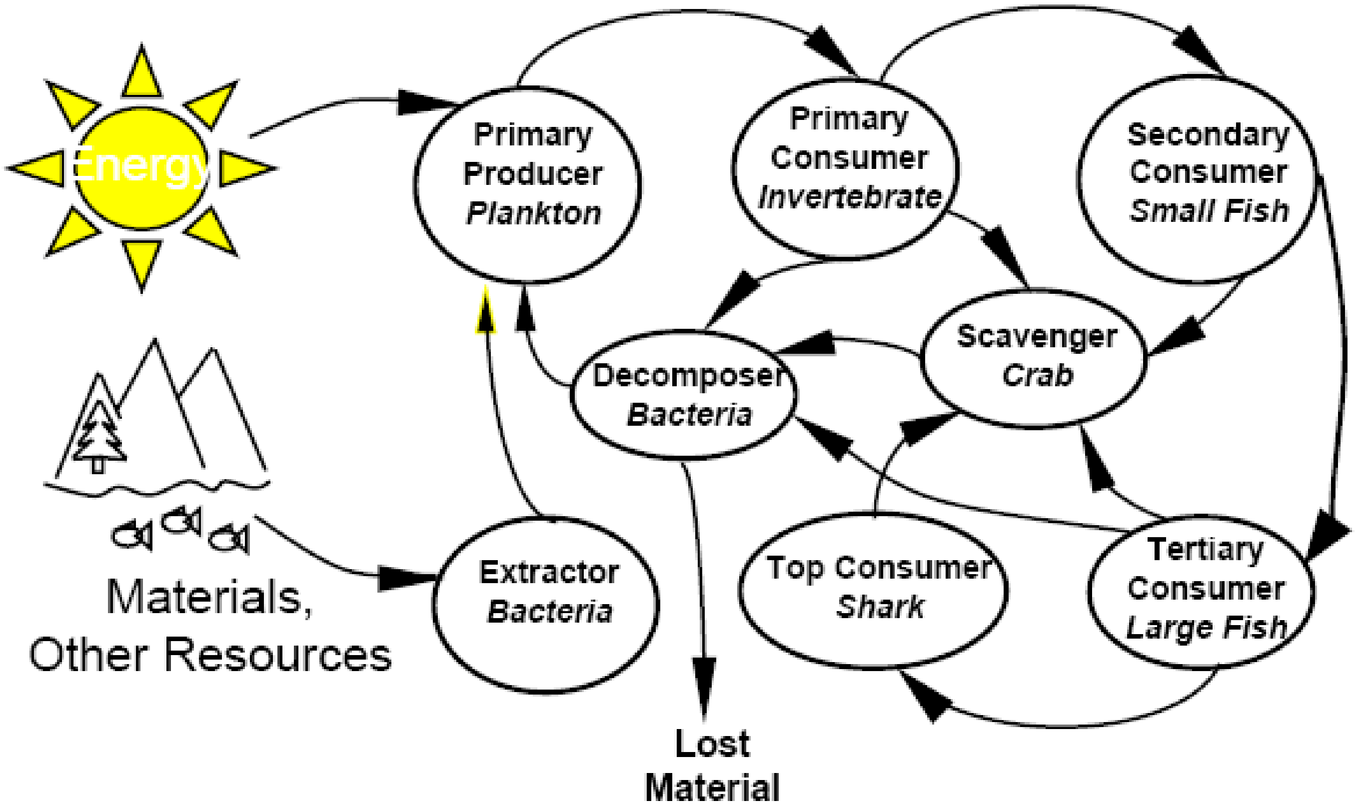
Selected IfaS Projects

- Zero-Emission- and biomass strategies for more than 40 cities, regions and universities
- Competence Network Environmental Technology RLP
- Circular Economy Concept for the city of Guiyang and the province Fujian, PR China
- CER and VER: Training and project development in Europe, Asia, Middle East and Latin America
- EU Innovation Projects: PROGRASS, SOLLET, VERC, SEMS
- Agenda 21/Company 21 training and consulting services in RLP
- PV-based electrification of rural areas in Rwanda, Africa
- Analysis & regional implementation of biomass-projects in Germany, Turkey, Chile, Brazil, China, Morocco
- .....

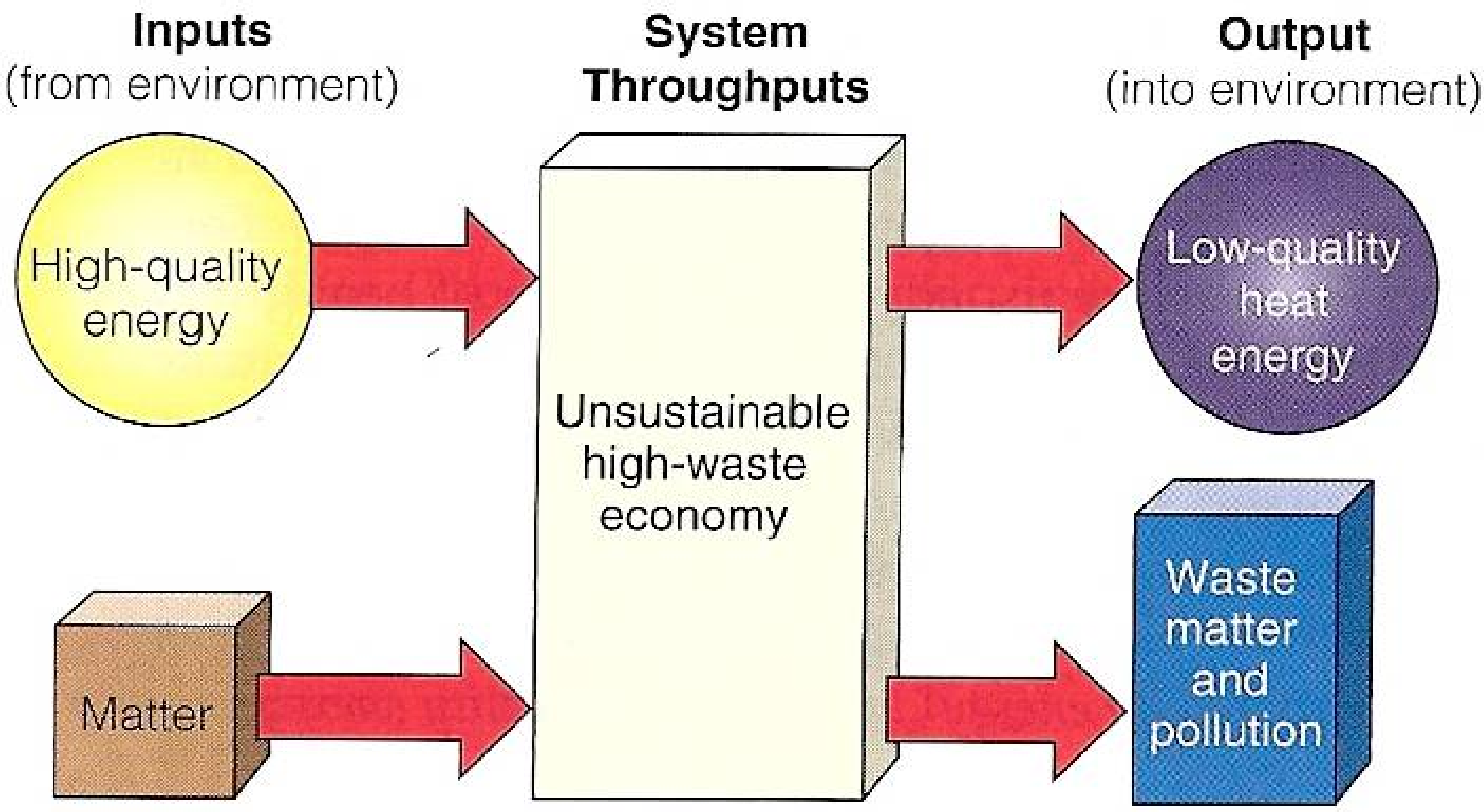
Selected IFAS projects (ctnd.)

- Biomass master plan Morocco (2008-2010)
- Biomass potential study Rhineland Palatinate (2001 -2005)
- Biomass master plan for several counties in Germany (Koblenz, Mayen, Kusel,Ahrweiler)
- Material Flow Management Master Plan for Antalya (Turkey), Krusevac (Serbia), Curitiba (Brazil)
- MFMMP county of Barnim (Germany)
- Feasability study for Jatropha plantation in Quena (Egypt)
- Bioenery village Grimburg
- Zero Emission Villages Weilerbach, Nalbach, Usedom, Barth etc.

Mature eco-system



Our present economy



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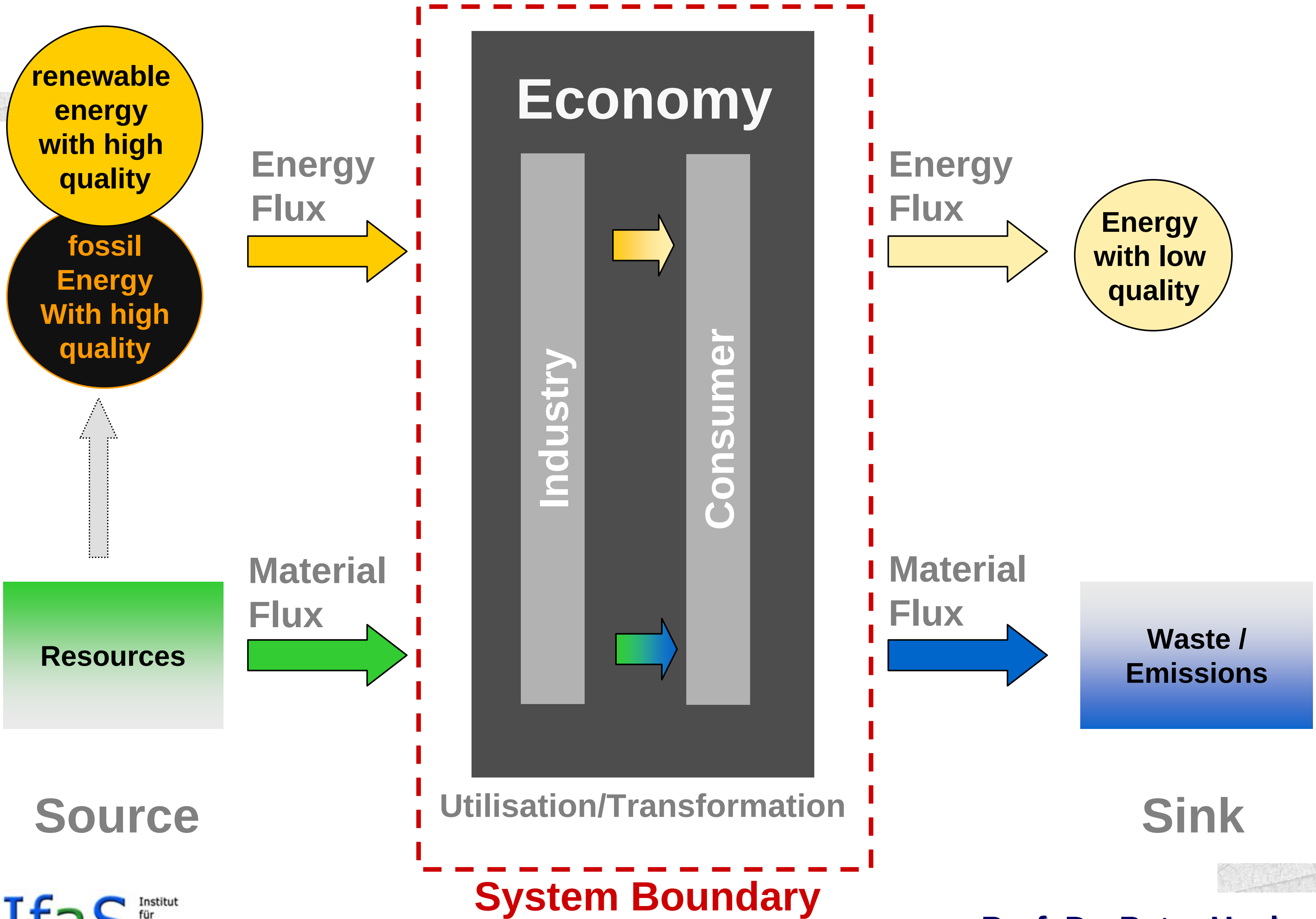
Economic System (linear)



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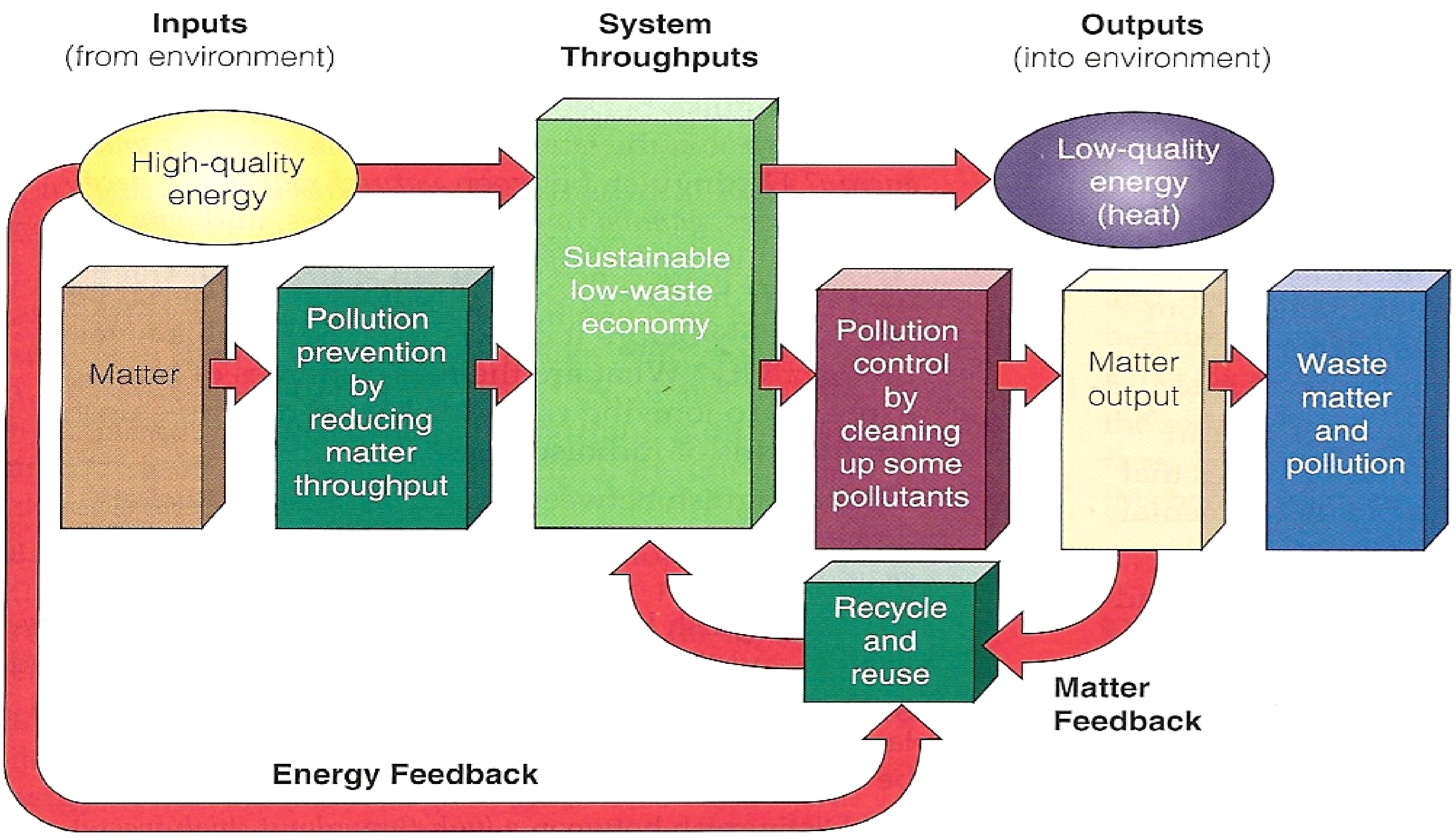
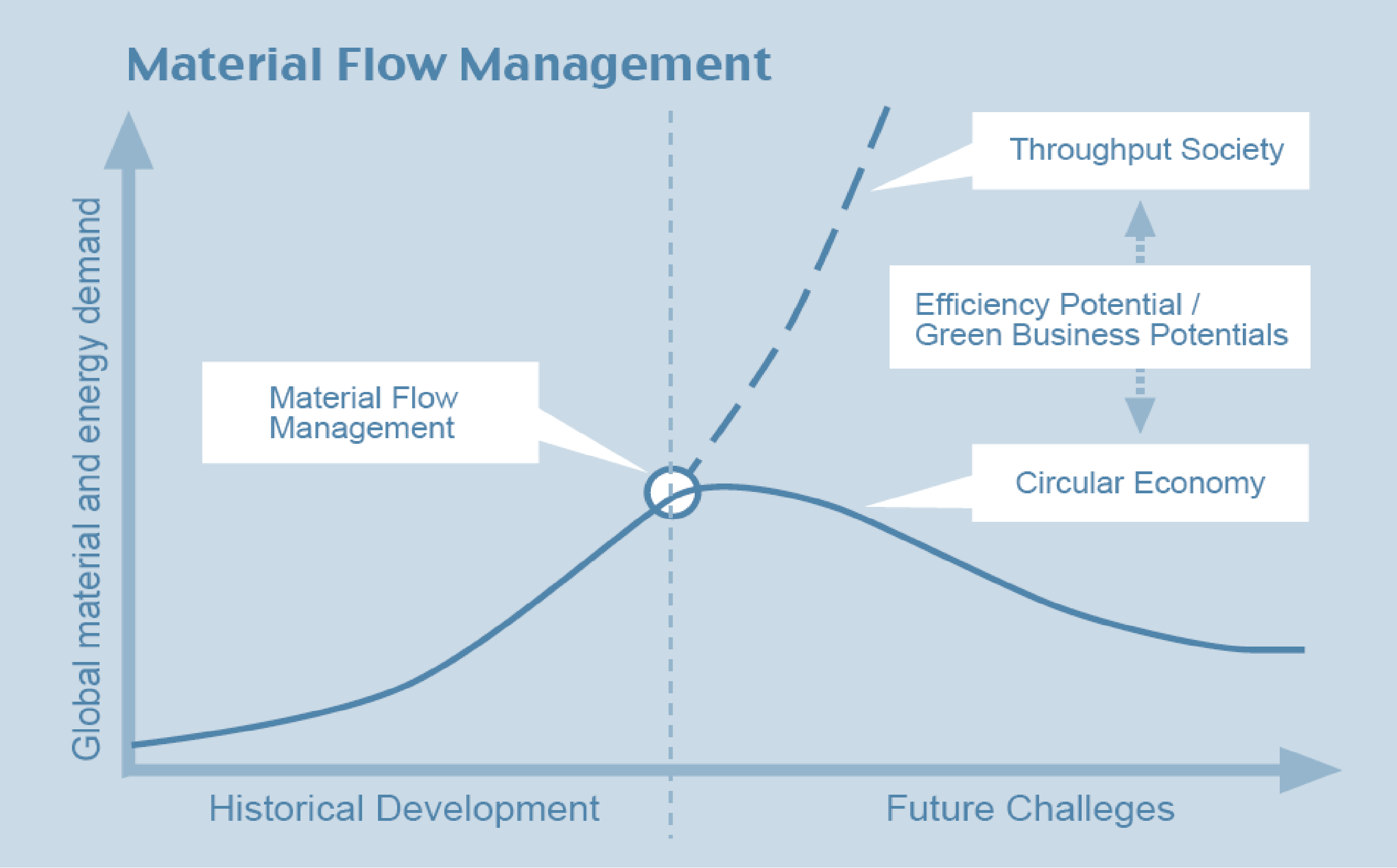
More sustainable society



MFM: A tool for Green Business Development



Consequences for sources

- Global Resource Shortage
  - Energy sources
  - Raw Materials
  - Water / Food
  - Etc

➡ Final depletion of various raw materials

➡ Increasing cost for resource consumption

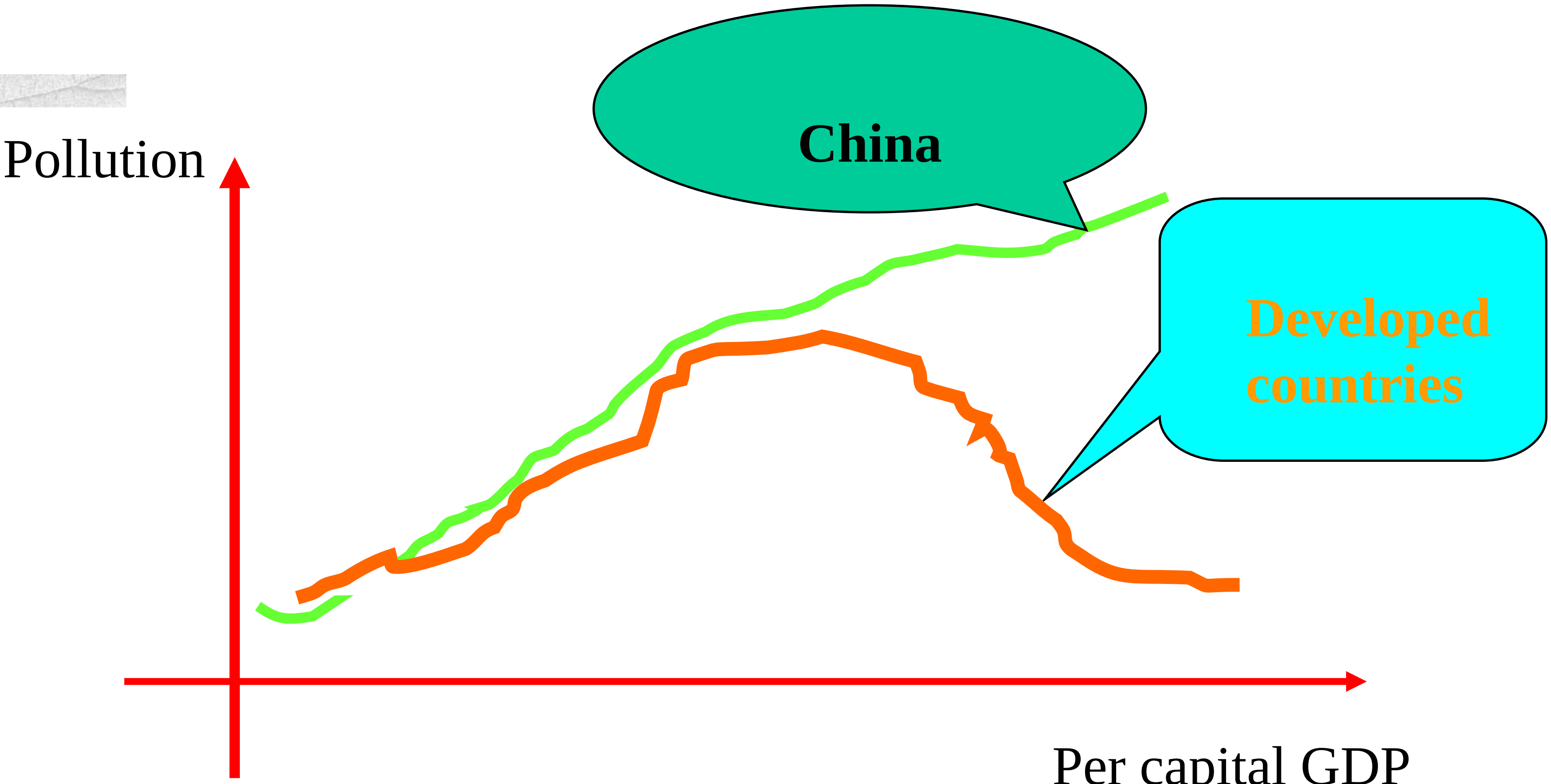
Consequences for sinks

- The earth sinks are depleted
  - Climate Change
  - Water Contamination
  - “Waldsterben”
  - etc

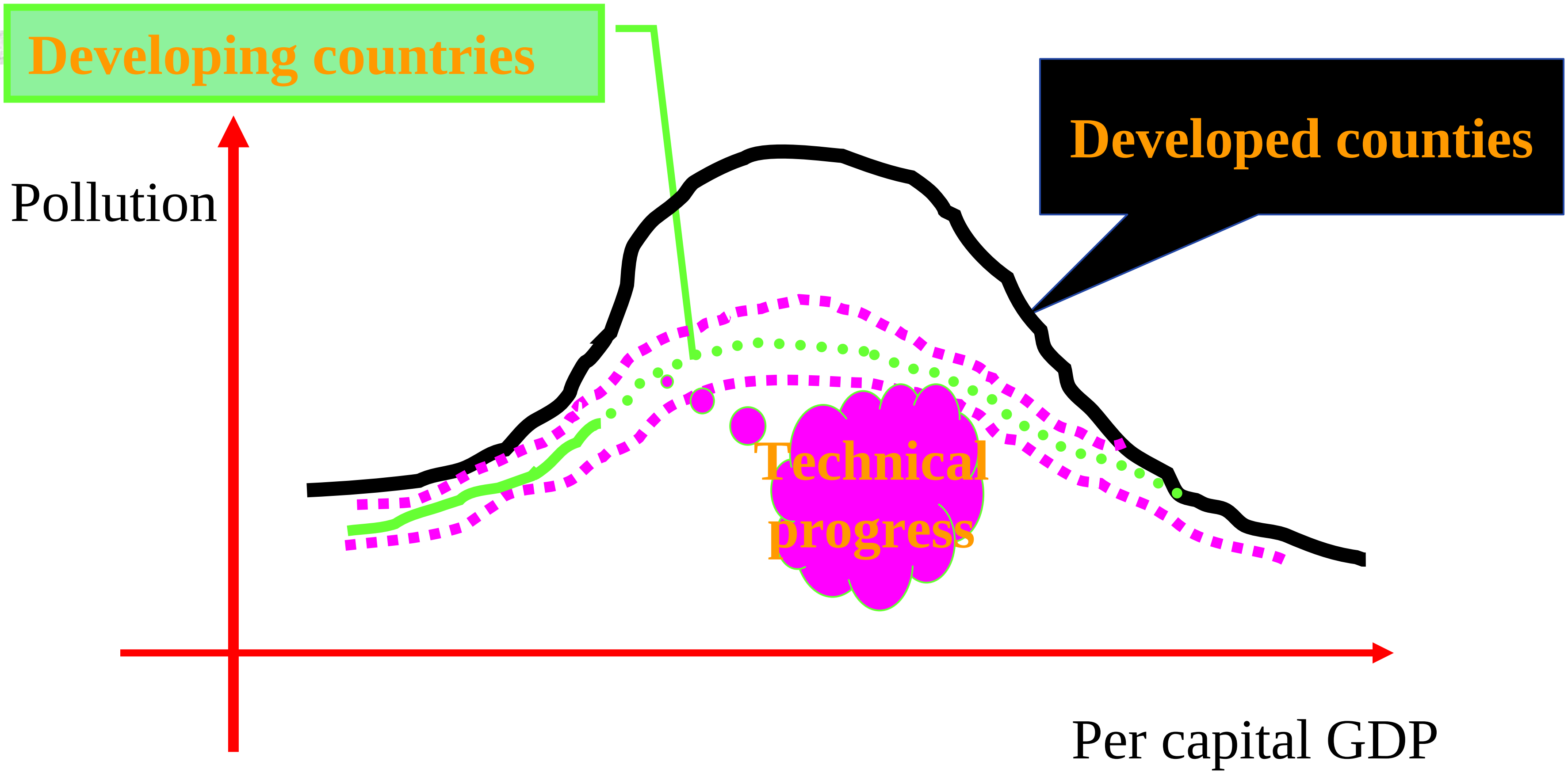
➡ The carrying capacity is stretched at the edge

➡ Increase macroeconomic liabilities due to the creation of new sinks or consequential damages

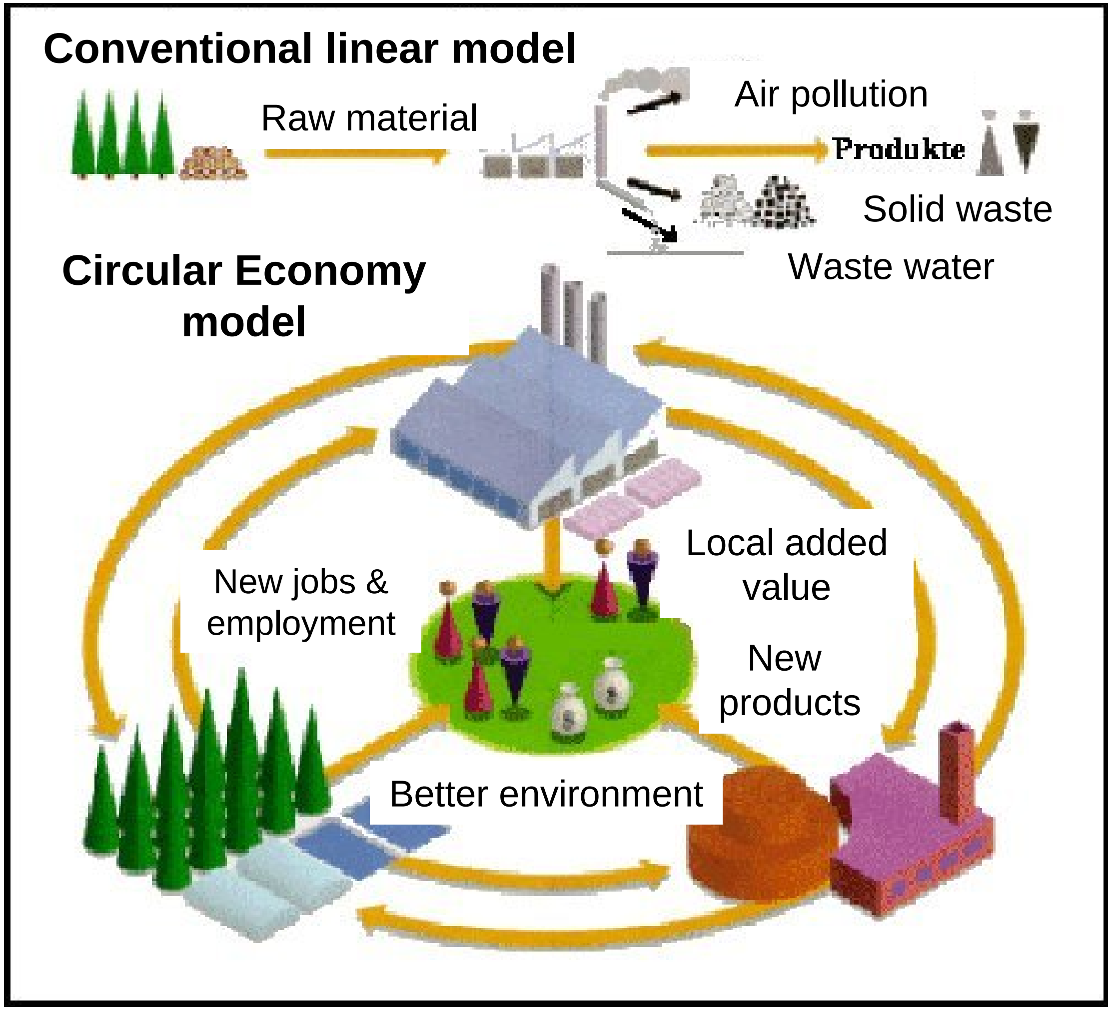
The western experience!



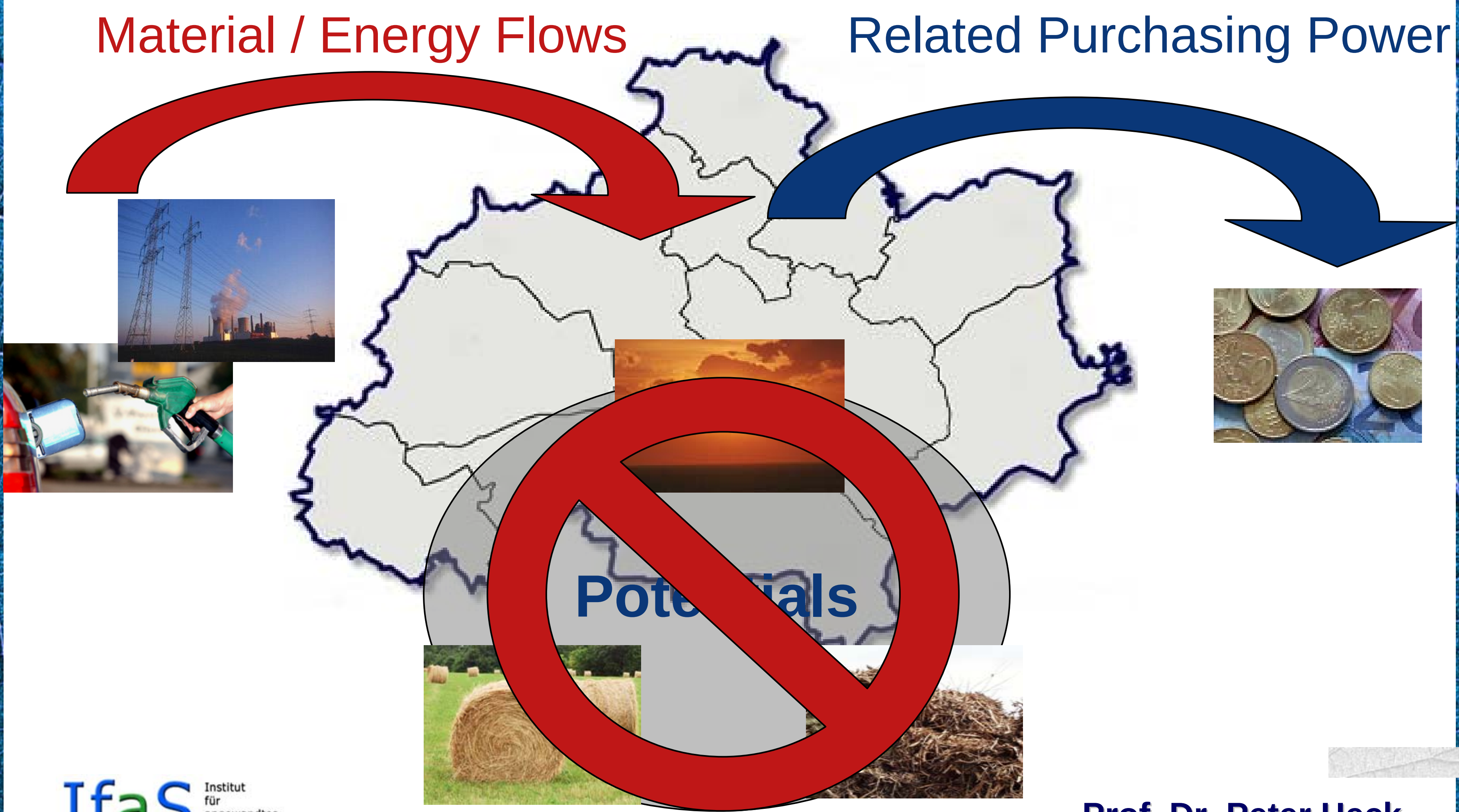
Frog leaping into a Circular Economy



Conventional linear model vs. CE-Model



Present Throughput Society (without MFM approach)



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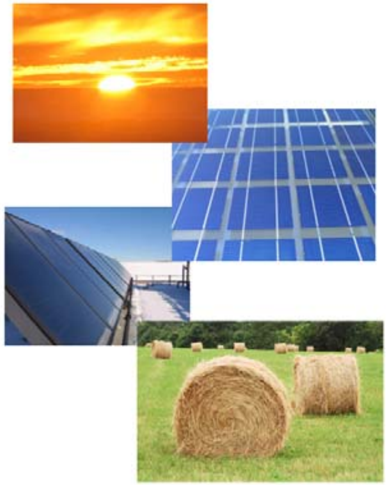
MFM Key Material Flow Potentials in Regions

z.B.

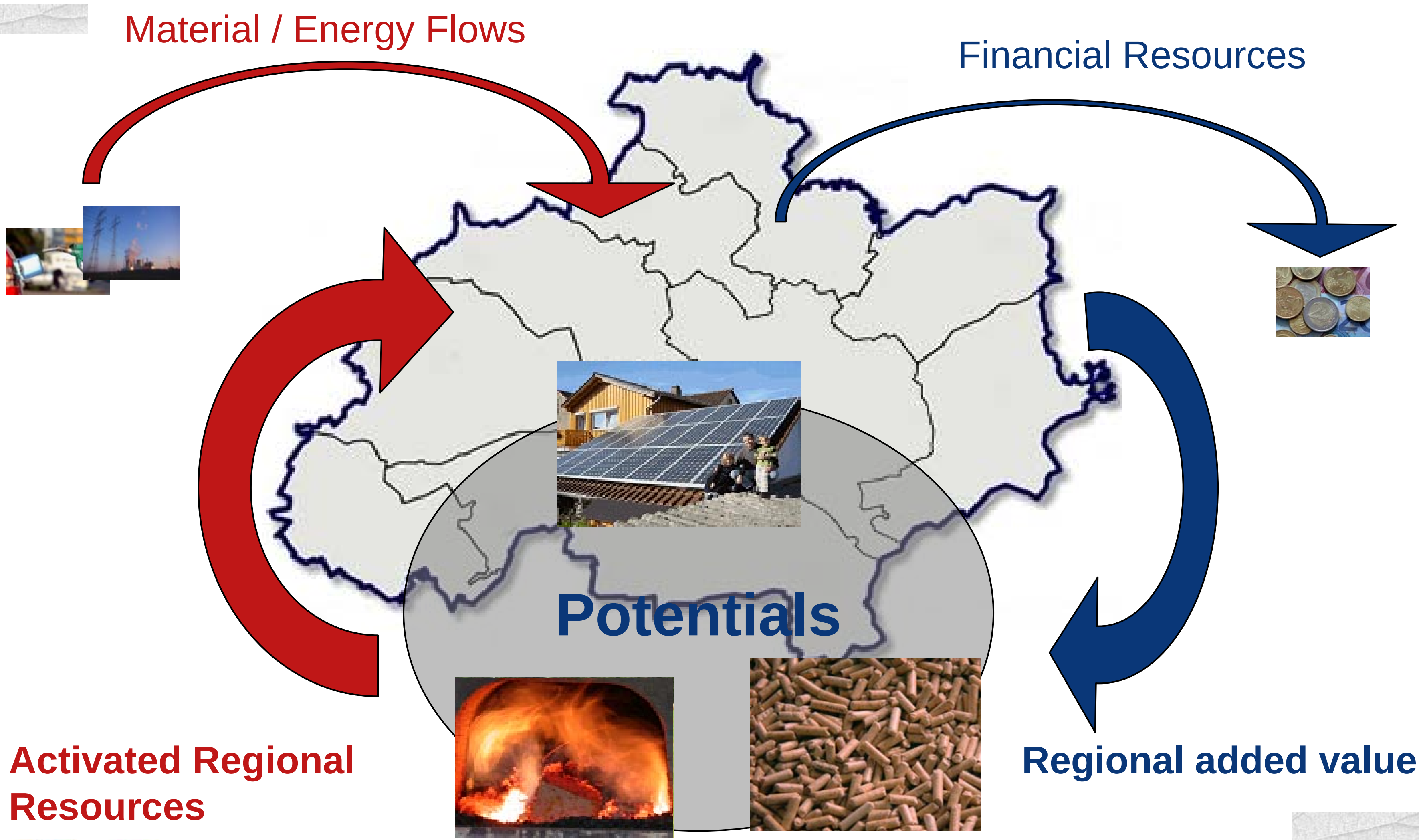
- **Water/Waste Water**
- **Sewage Sludge**
- **Fossile Primary Energy Sources**
- **Fossile End energy (electricity, heat, cold,)**
- **Renewable Energies**
- **Forest and Forest Residues**
- **Greenery Residues**
- **Agriculture (production potential and waste)**
- **Urban Waste**
- **Buildings and Infrastructure**
- **Waste Fats and Oils**
- **Traffic and Mobility**
- **Special aspects like e.g. Tourism**

Foto: H.-G. Oed

Foto: H.-G. Oed



Circular Economy with MFM approach



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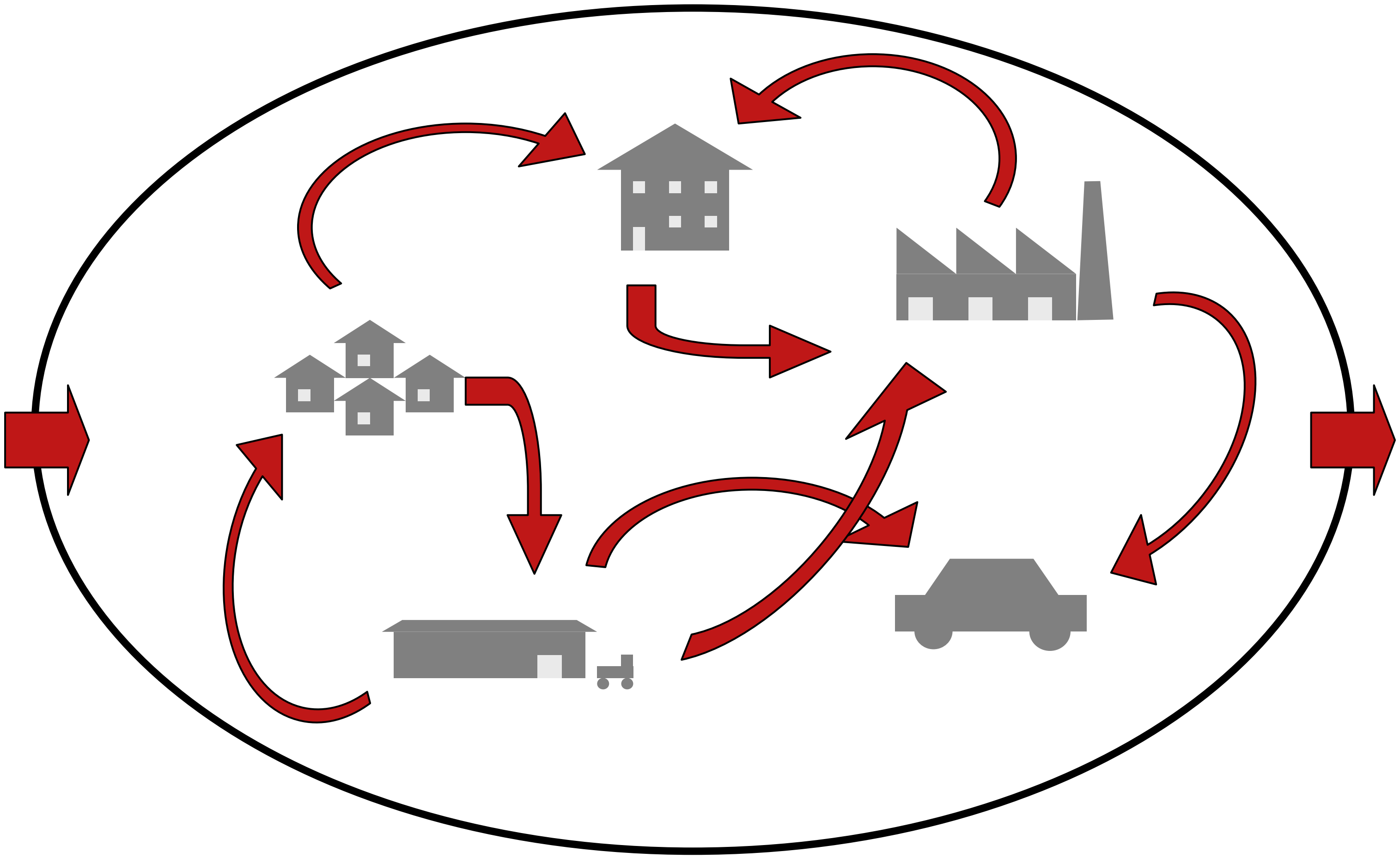
Holistic Regional Material Flow Management



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Definition of MFM

Definition:

„Material-Flow-Management means the goal oriented, responsible, integrated and efficient influencing of material systems.

The goals are given by ecological and economical areas and by observing social aspects."

Enquête-Commission of the German Bundestag: „Protection of human beings and environment", 1994, p. 259

MFM Methodology

- Definition of Material and Energy Fluxes to be analysed and optimised
- Material Flow Analysis (On site visits, questionnaire, interviews, statistical data)
  - Quantities of defined material and energy fluxes
  - Qualities of defined material fluxes
  - Place of Origin/Logistics of defined material fluxes
- Identification of major efficiency and optimisation potentials
- Identification of regional key persons and decision makers

MFM Methodology (cont.)

- Formulation and Development of key MFM projects in close cooperation with key persons
- Business Planning and Environmental Impacts Assessment for key projects
- Setting up Joint-Venture for the Project Implementation
- Aggregation of Key Project and set up of Circular Economy Holding or MFM Holding

Regional MFM Development Process

Material Flow Analysis

- Definition of the system boundary [e.g. administrative region]
- Evaluation the current system-immanent material fluxes and energy demand and production structure
  - Choosing the main sectors of industry, agriculture, solid urban waste, and energy supply
- Identifying key persons and networks in the field of most important material fluxes

✓ *Results:*

Deeper understanding of regional material flow system, limitations, inefficiencies, real costs and potentials.

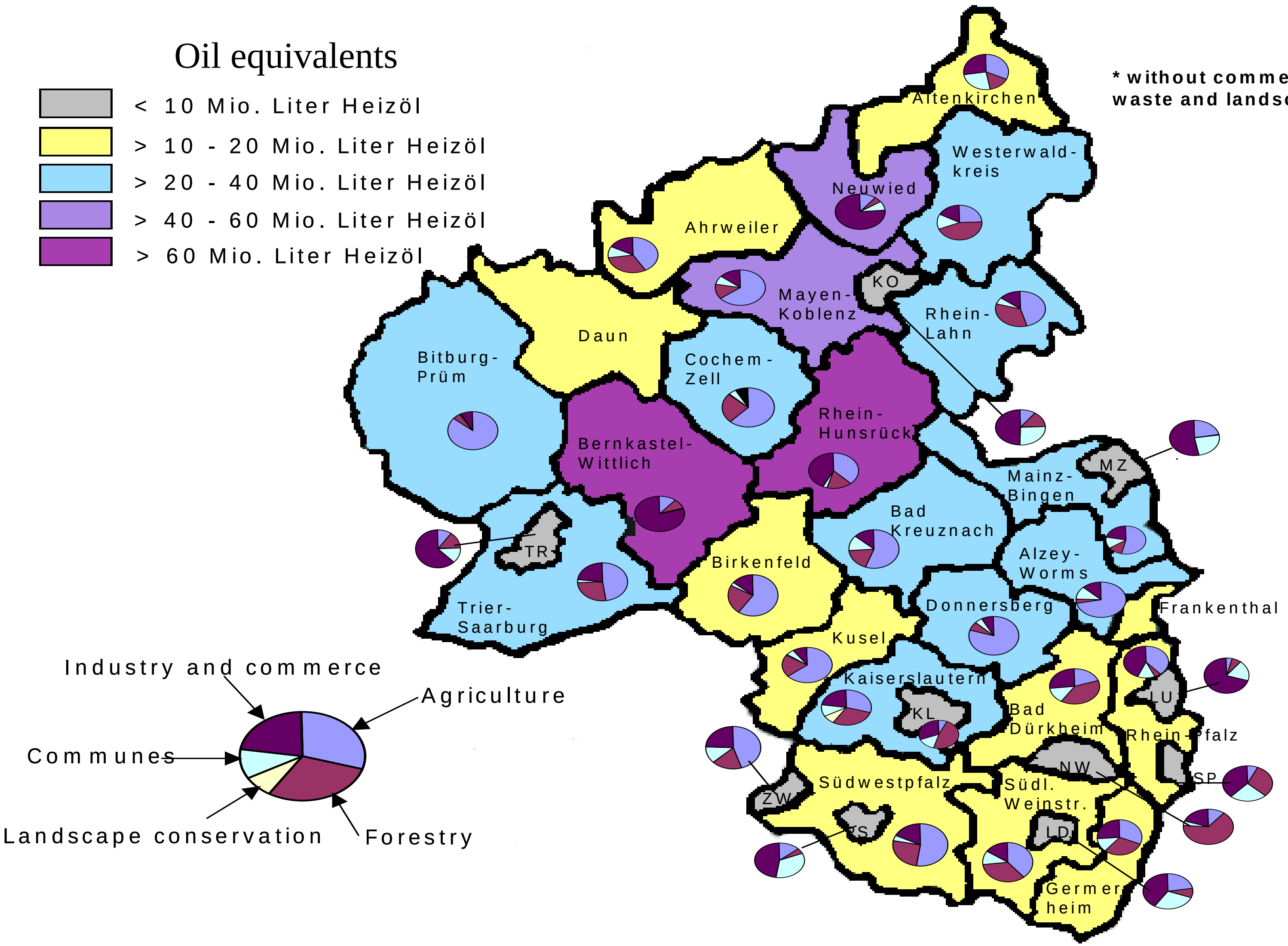
Evaluation of MFA Data

- Understanding the strengths and weaknesses of the existing system
- Understanding the official and unofficial rules guiding and organizing the existing MFM system
- Investigating the full cost of the existing Material and Energy Flux System
- Calculating the impact on the economy (regional added value and the environment (especially carbon dioxide and related emissions)

Identification of potentials

- Identify energy and material optimisation opportunities in the industry, private and administrative sectors in the fields of logistics, production and consumptions
- Identify embedded energies sources and future energetic utilisation e.g. sewage sludge, organic waste, etc.
- Identify additional financing options like GHG emission trading
- Identify bilateral cooperation and technology transfer models like BOT

Available potentials from biomass in mio. liter oil equivalent per year in RLP*



* without commercial organical waste and landscape conservation

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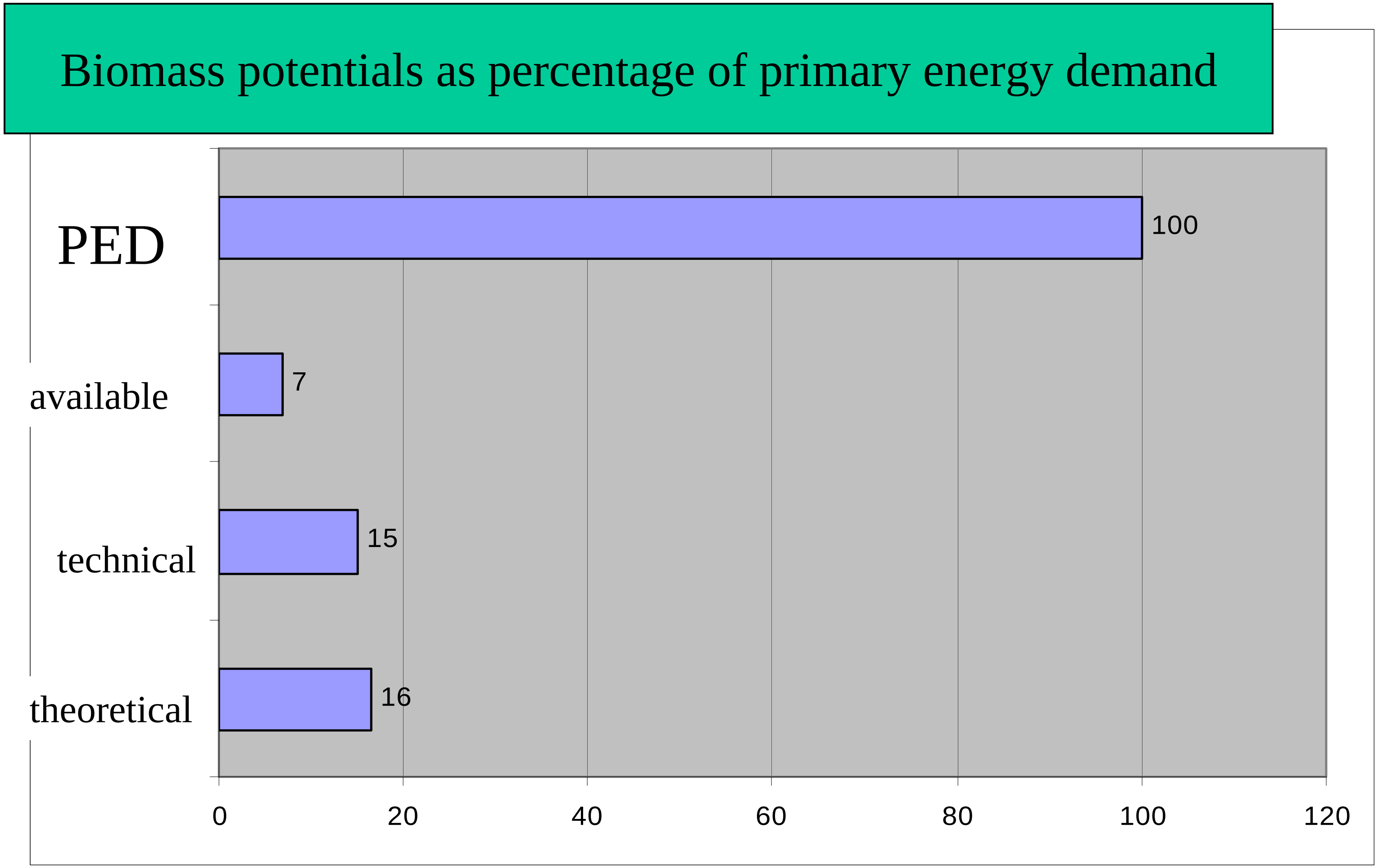
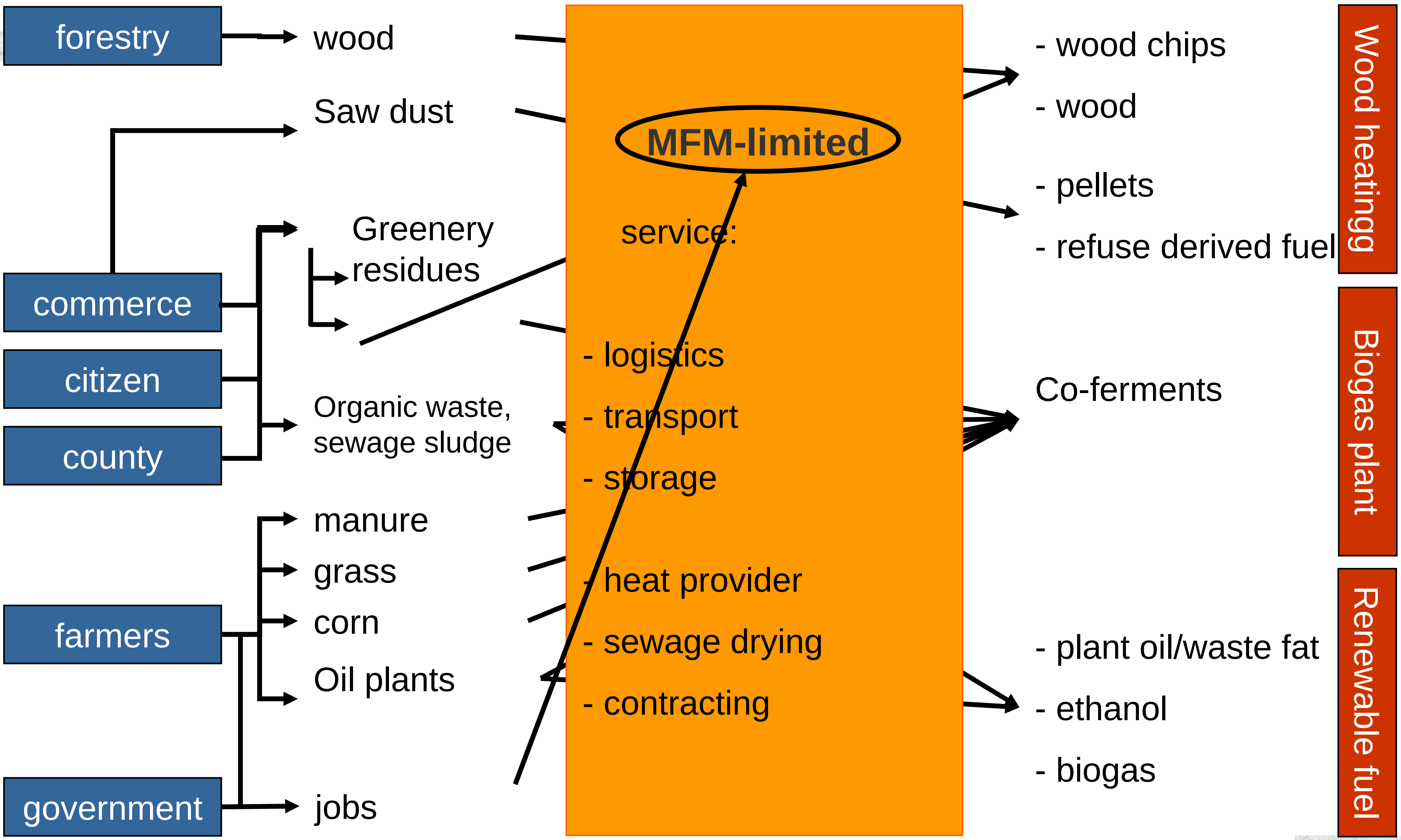
Biomass potentials in Rhineland Palatinate (Germany)



Organization of material flow management



Business plan development

- Full cost calculation of existing system and proposed MFM system
- Market analysis and market development for new products
- Developing separated business plans for the key projects
- Aggregating the detailed project business plans to a regional master plan on Circular Economy
- Utilising the Kyoto Flexible Mechanisms: Creation of the Project Identification Note (PIN) and Project Document Design (PDD)

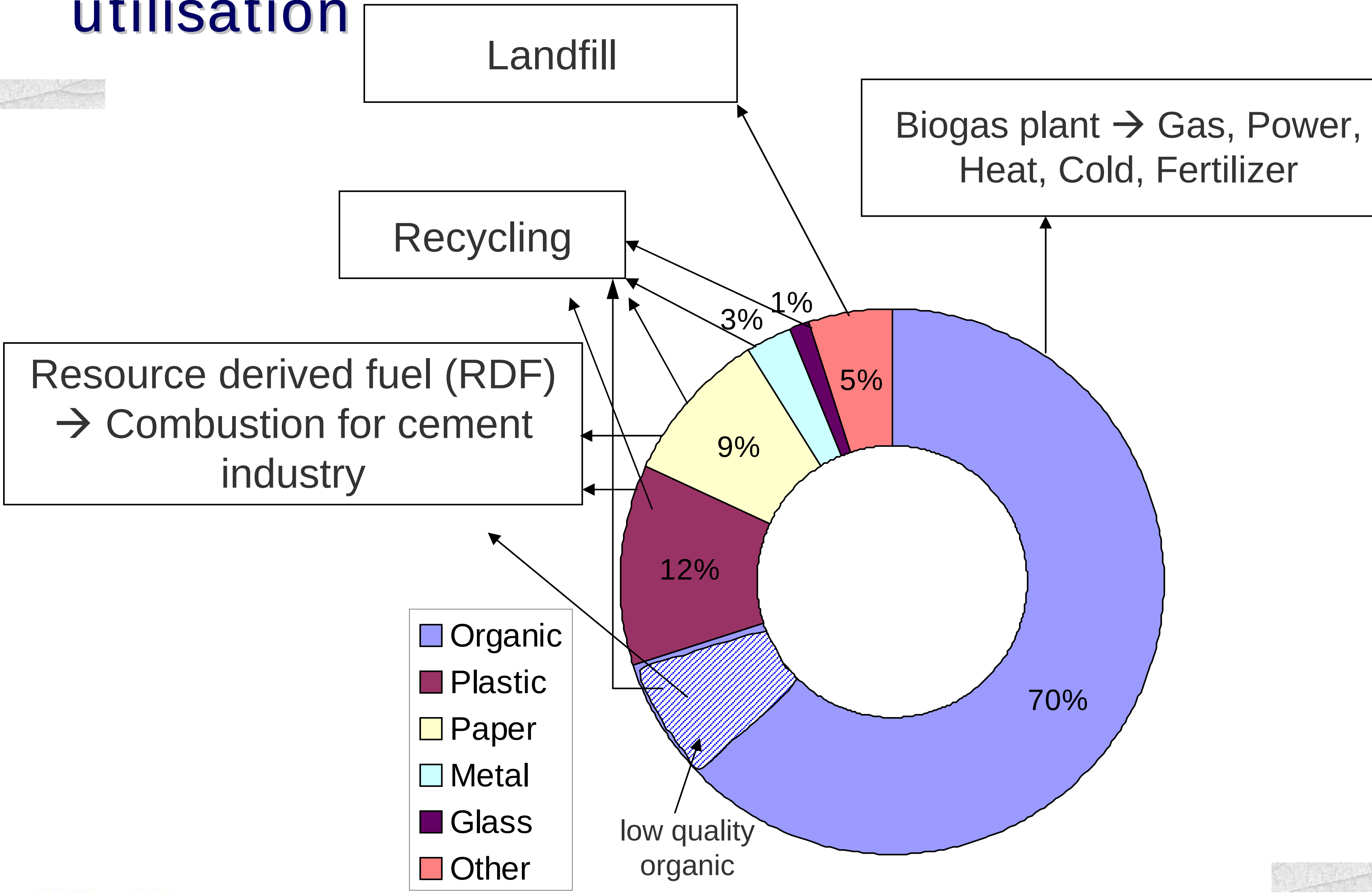
Implementation of Master plan

- Setting up a CE project implementation and management team
- Setting up BOT schemes for the key projects and starting joint venture talks between local and foreign companies (together with government)
- Implement training and capacity building programmes for local technicians
- Implement PR campaigns to increase the public awareness on CE
- Starting a new MFA to create new project ideas

Case studies

- Waste
- Waste water
- Energy

Contents of Waste and their possible utilisation



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Waste „Management“ in Developing Countries….

Actual effects from waste treatment in landfills

- Large transportation efforts
- Treatment costs for leachate
- Global warming
- Additional energy required for treatment on landfill
- External effects by methane emissions, water pollution
- Energy content in waste is not being used
- No creation of new jobs
- Landfill space will be used up (additional investment costs)
- Difficulties in finding new landfill space
- → negative added value!!!

*Germany Historical Development in Waste Management**

1. period / „from chaos to order“ — 1945 - 1972

2. period / „from waste dumping to recycling- and waste management“ — 1973 - 1996

3. period / „searching for a new order“ — 1997 - 2003

Integrated material flow management **?** — > 2004

* based on: Schenkel, W., Zur Geschichte der Abfallwirtschaft in Deutschland, Müll und Abfall 12/03

Goals of the German waste management policy

Waste has to be

- avoided
- reused and recycled
- disposed of properly

Waste management plans serve to implement those targets and goals

Treatment of the remaining waste fraction / 1

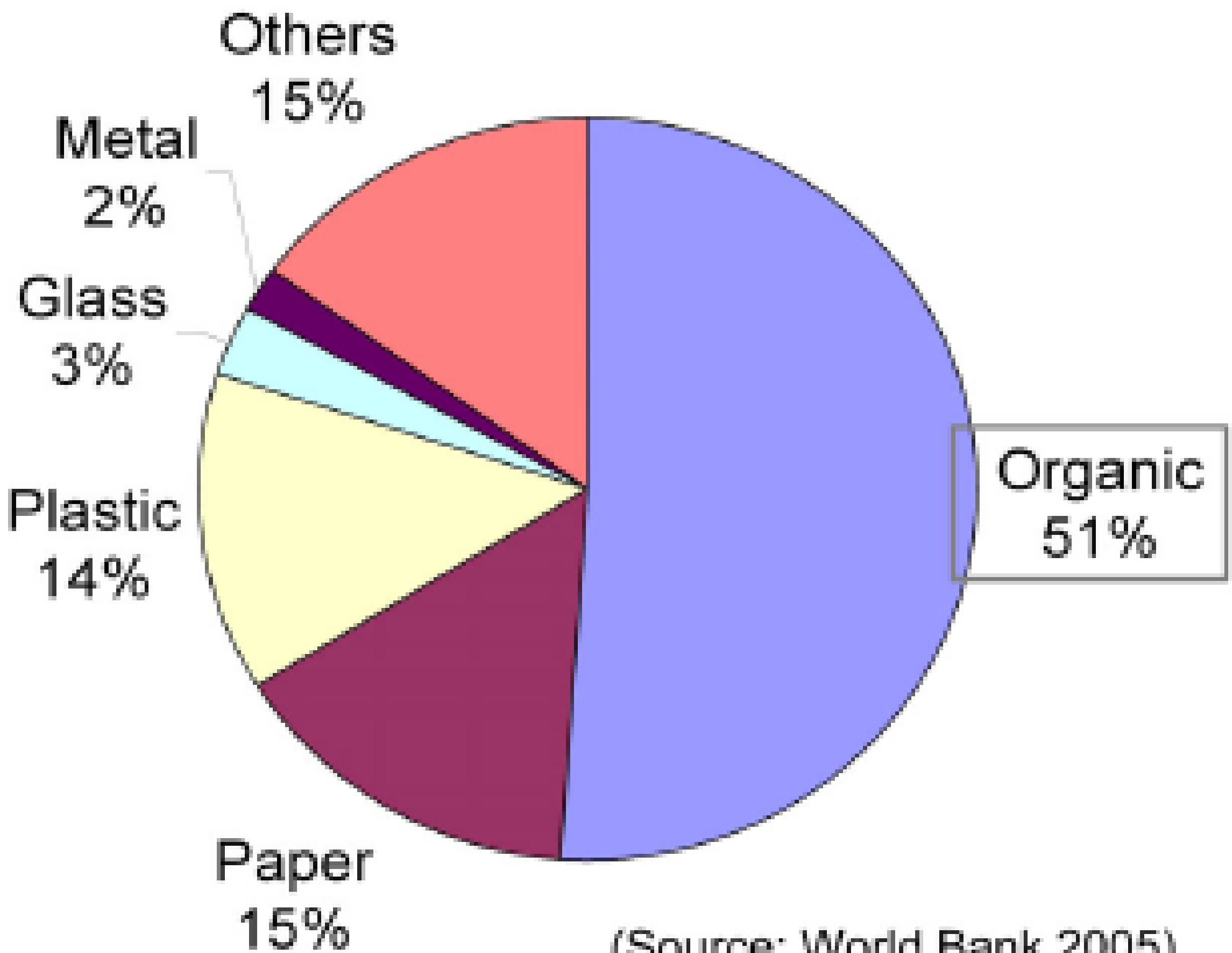
The landfilling of untreated wastes is no longer allowed since 2005 !

Greenery residues for heating of schools and public buildings

Pfalzwerke

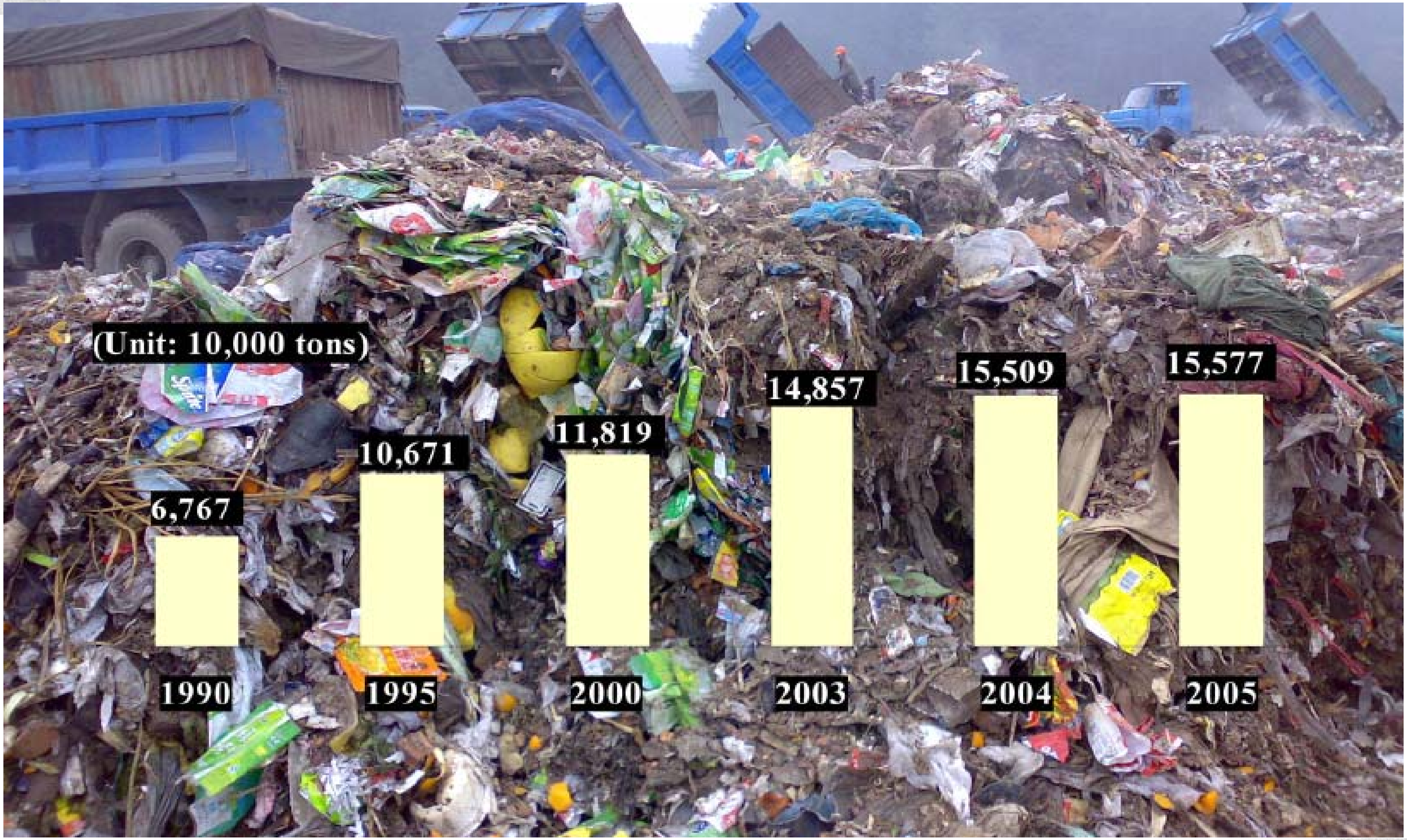
Pfalzwerke

Urban waste composition in China

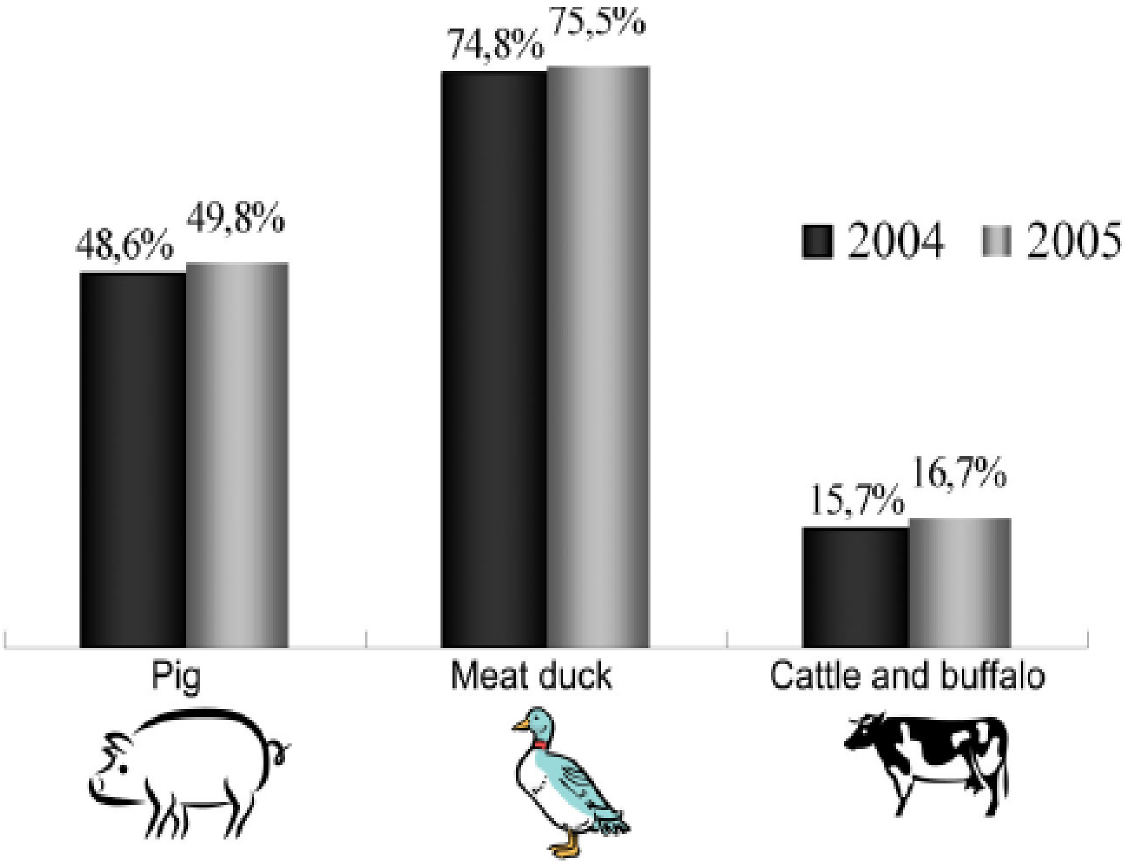


(Source: World Bank 2005)

Organic waste potential in China

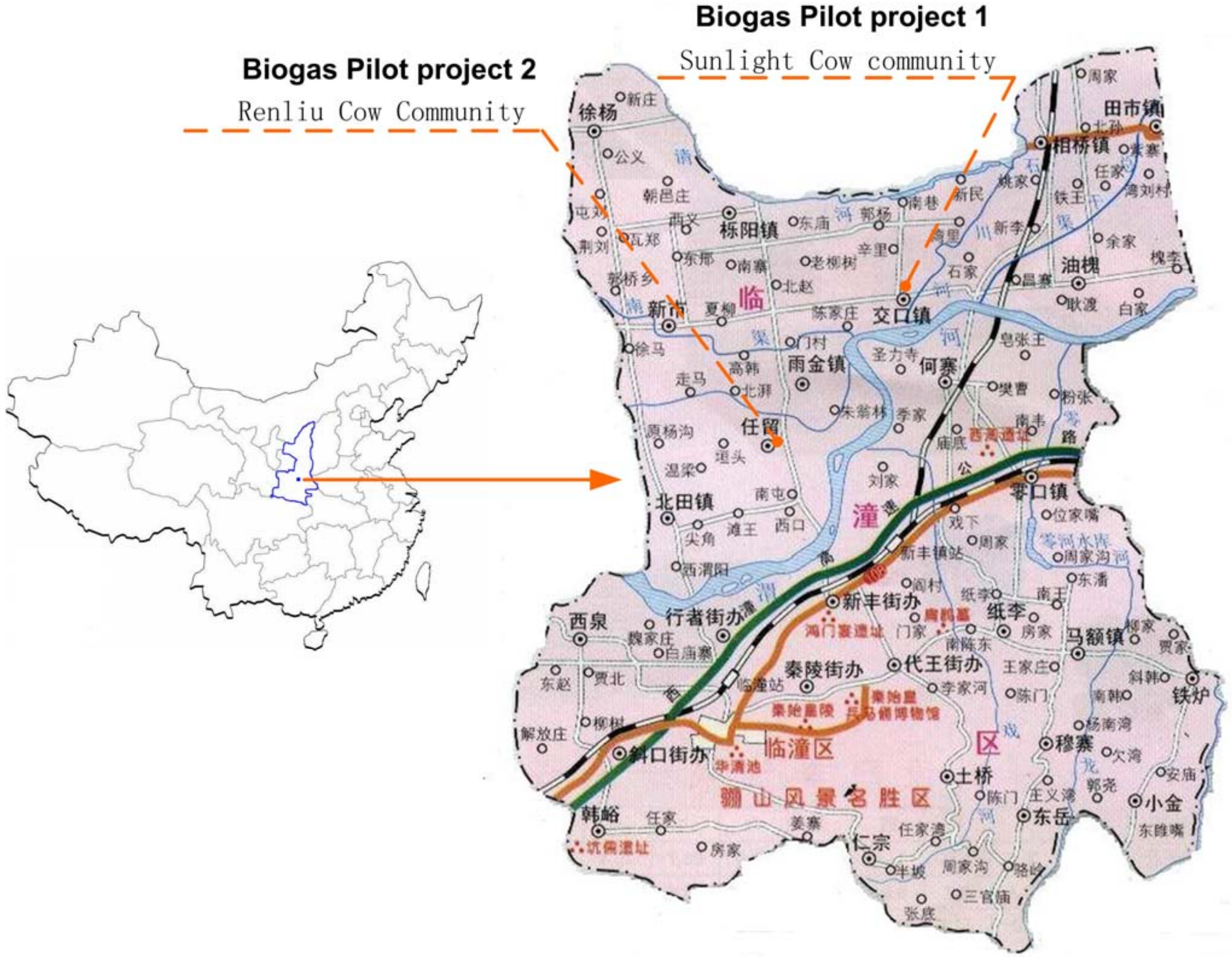


Animal waste potential China



(Source: Liu, 2006)

Location



Shaanxi Province, Xi'an City, Lingtong district

Pollution I: Sunlight cow community

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Photos in 2006.8 © IfaS

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Pollution II: Renliu cow community

Photos in 2007.1 © IfaS

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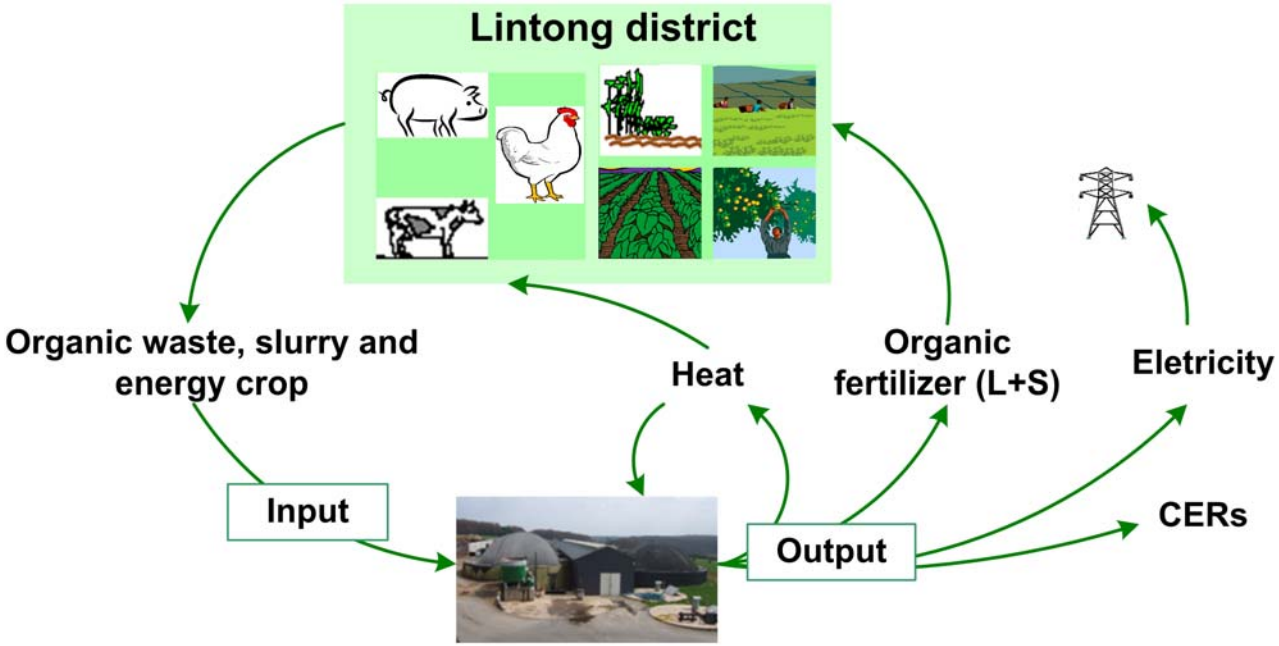
Overall data: other organic residues

Other organic residues	农业残余物	Quantity (10, 000t/y)	Market price RMB/kg
Corn straw	玉米杆	100	0.06
Wheat straw	麦秸	60	0.20
Wheat husk	麦壳	5	
Vegetable residues	蔬菜残余物	2	0.10
bran	麸皮	20	1.00
Corn husk	玉米皮	3	0.60

New vision for Lintong district



Establishment of integrated organic waste recycling system in Lintong

Project Goals

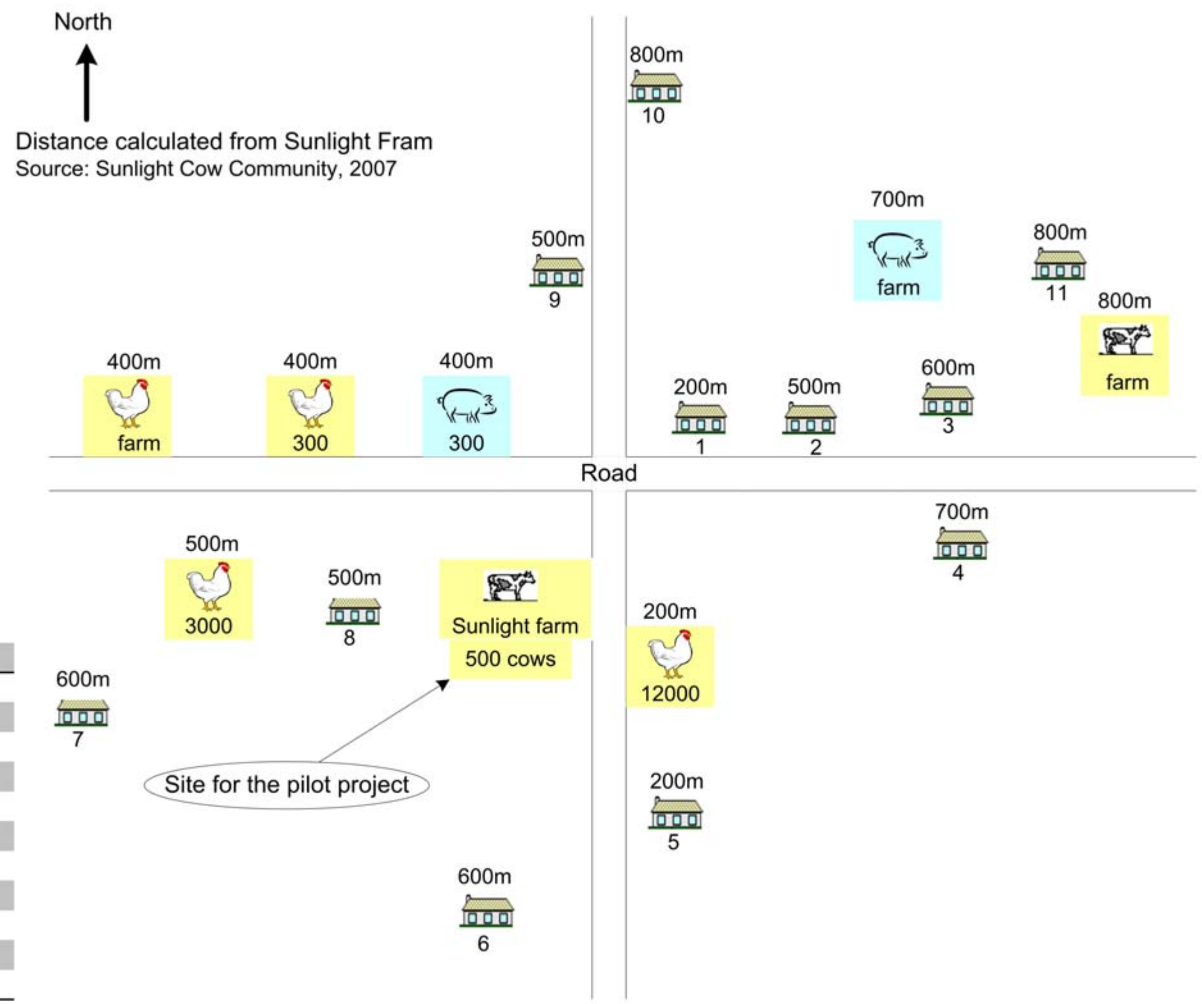
- Controlling pollutions
- Genrating renewable energy and organic fertilizer
- Providing district heat if the nearby households if possible
- Creating CERs if possible

Possible input substrates in the nearby area for the biogas plant at Sunlight cow community

Milk cow	Chicken	Pigs
500+	15300	300 +

No.	Name of villagers group	Quantity of househoulds
1	东庄组 Dongzhuang	55
2	照长组 Zhaochang	80
3	新张组 Xinzhang	70
4	张堡组 Zhangbao	70
5	东郝组 Donghao	65
6	西郝组 Xihao	60
7	双南组 Shuangnan	*
8	双北组 Shuangbei	*
9	念扬组 Nianyang	102
10	朱屯组 Zhutun	165
11	火苇组 Huoling	60

Sketch map of the biogas CHP pilot project site (Sunlight) in Lintong, Shaanxi



Potential areas for using district heating service suppled by the biogas CHP plant

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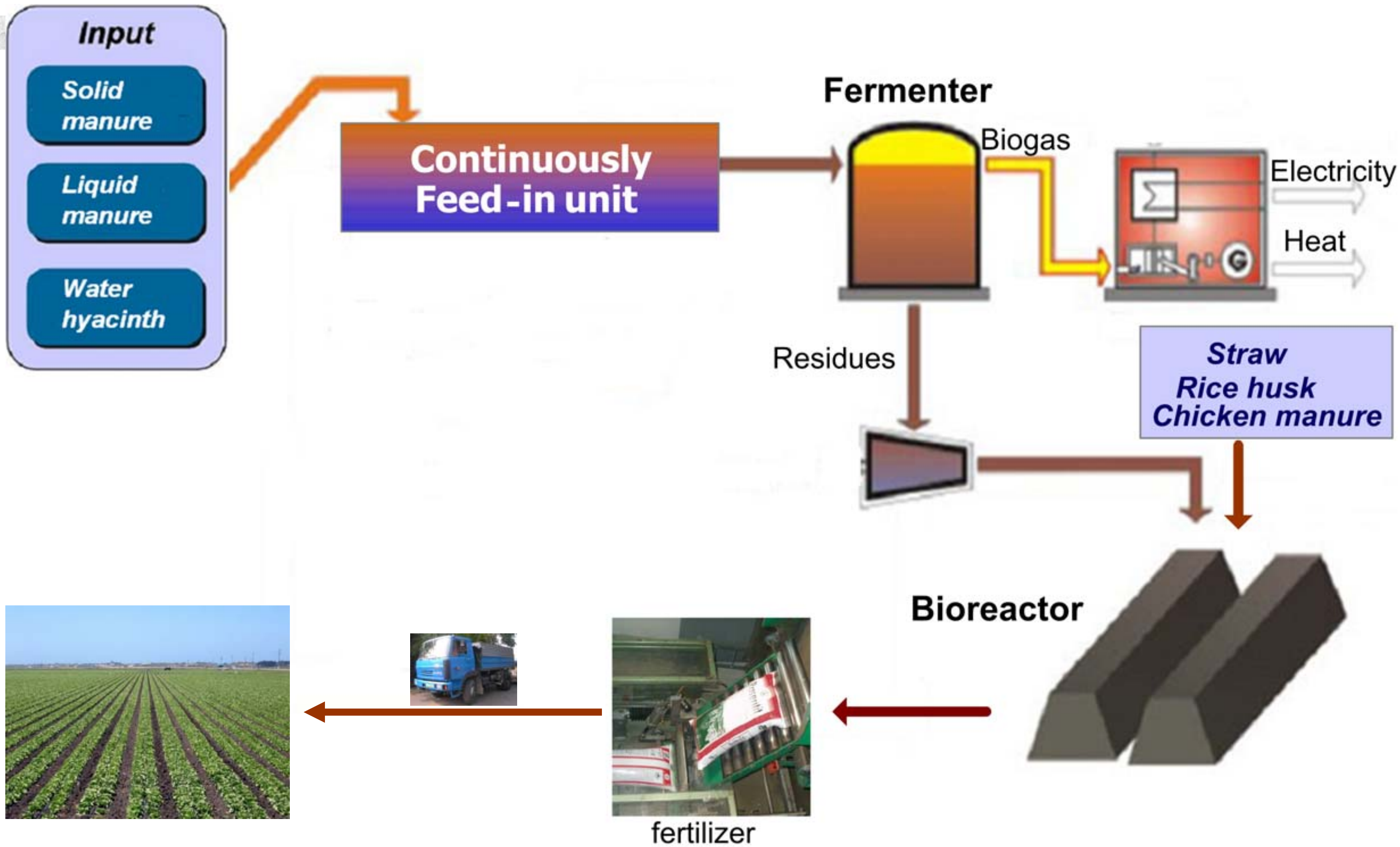
Technical concept



Theoretical energy potential from organic waste in China

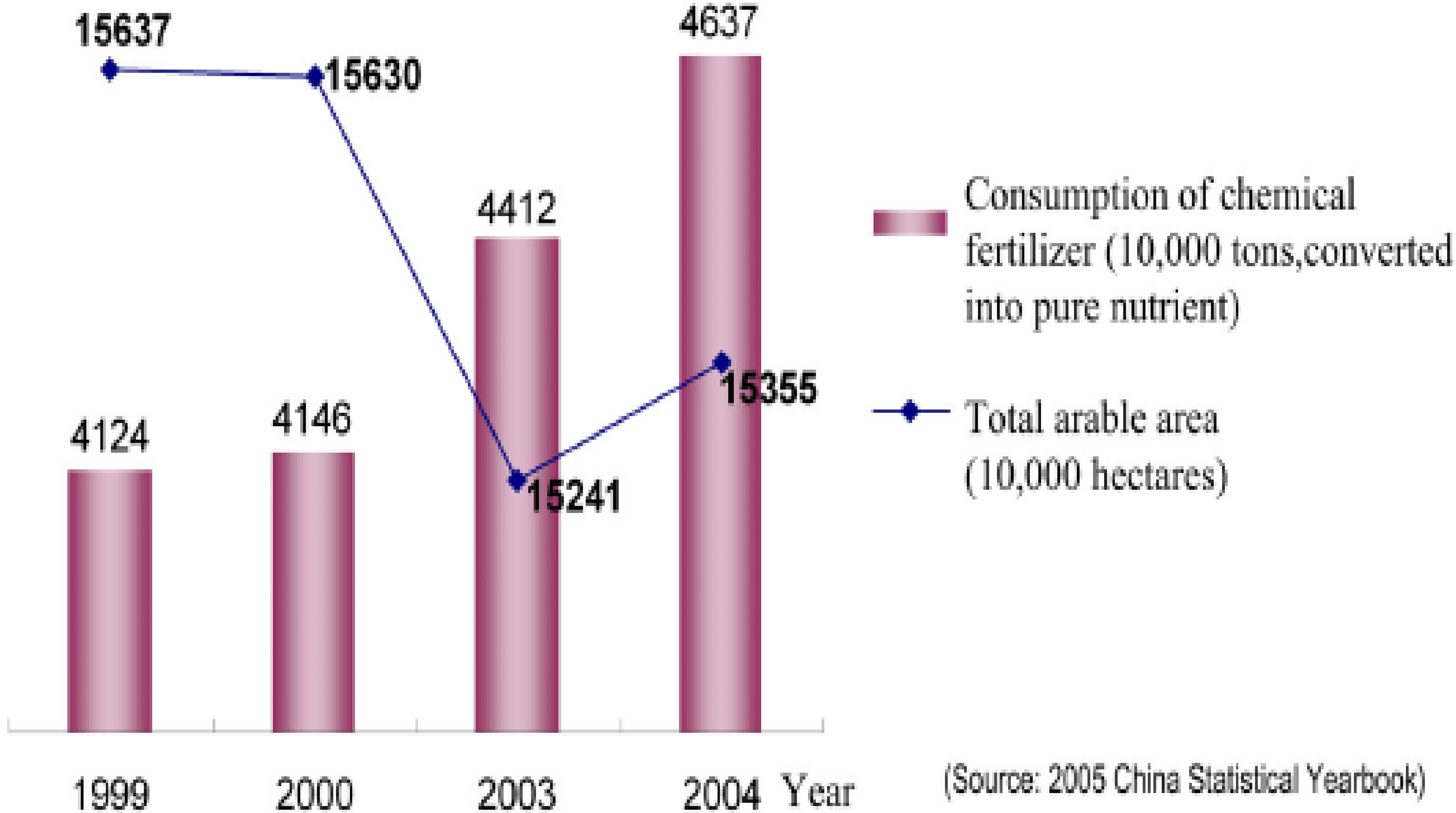
Theoretic energy potentials of biodegradable municipal waste (BMW) in China in 2005*

Heat 16.8 billion KWh

Electricity ~ 2000 MWel→ 14 billion KWh
= Electricity consumption of 65 Million people for non-production purpose in 2005 in China

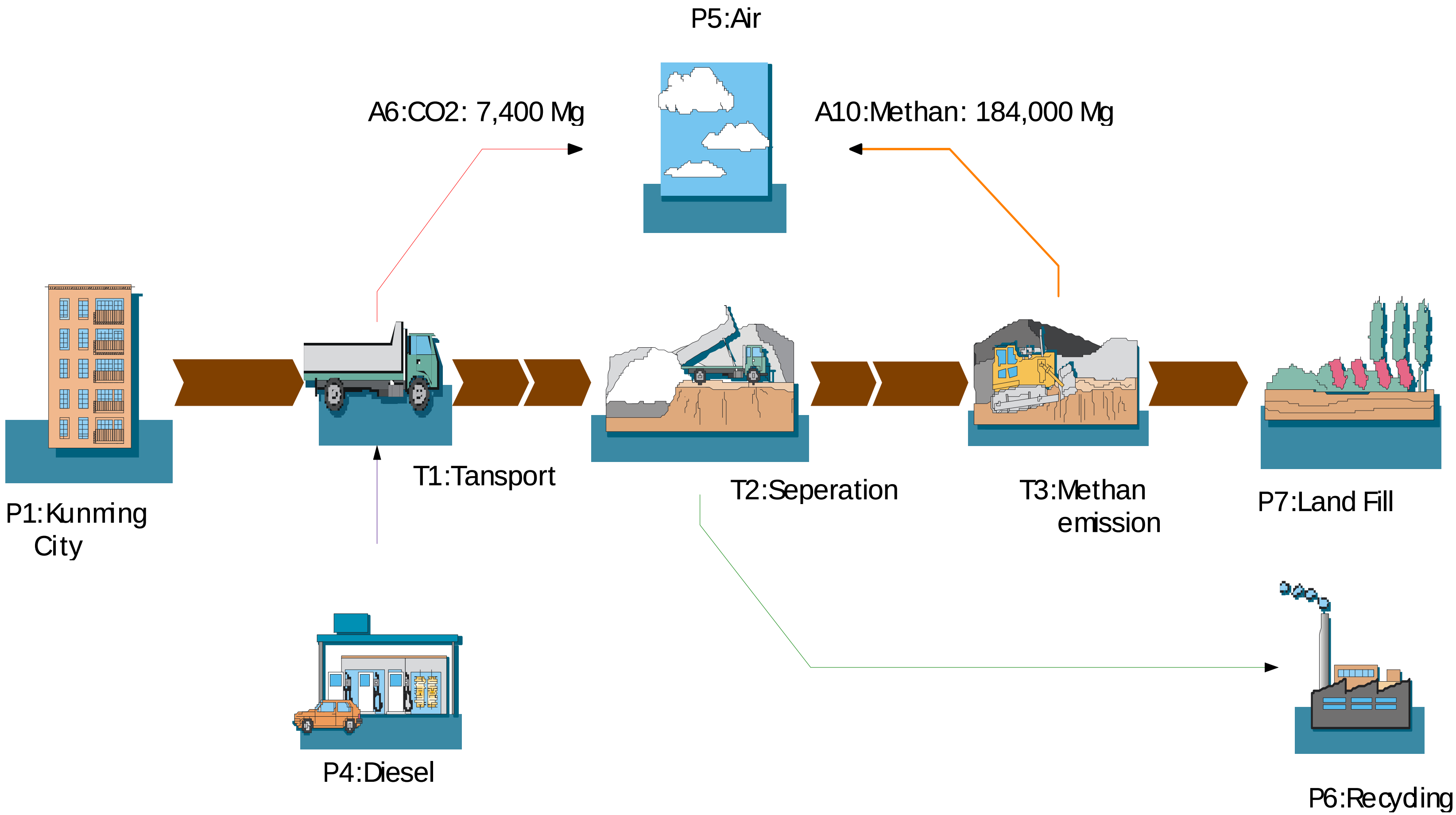
CO_2 reduction→13 million tons due to substitute of fossil fuel based electricity

Mineral fertilizer demand



(Source: 2005 China Statistical Yearbook)

Environmental Modelling: Actual situation



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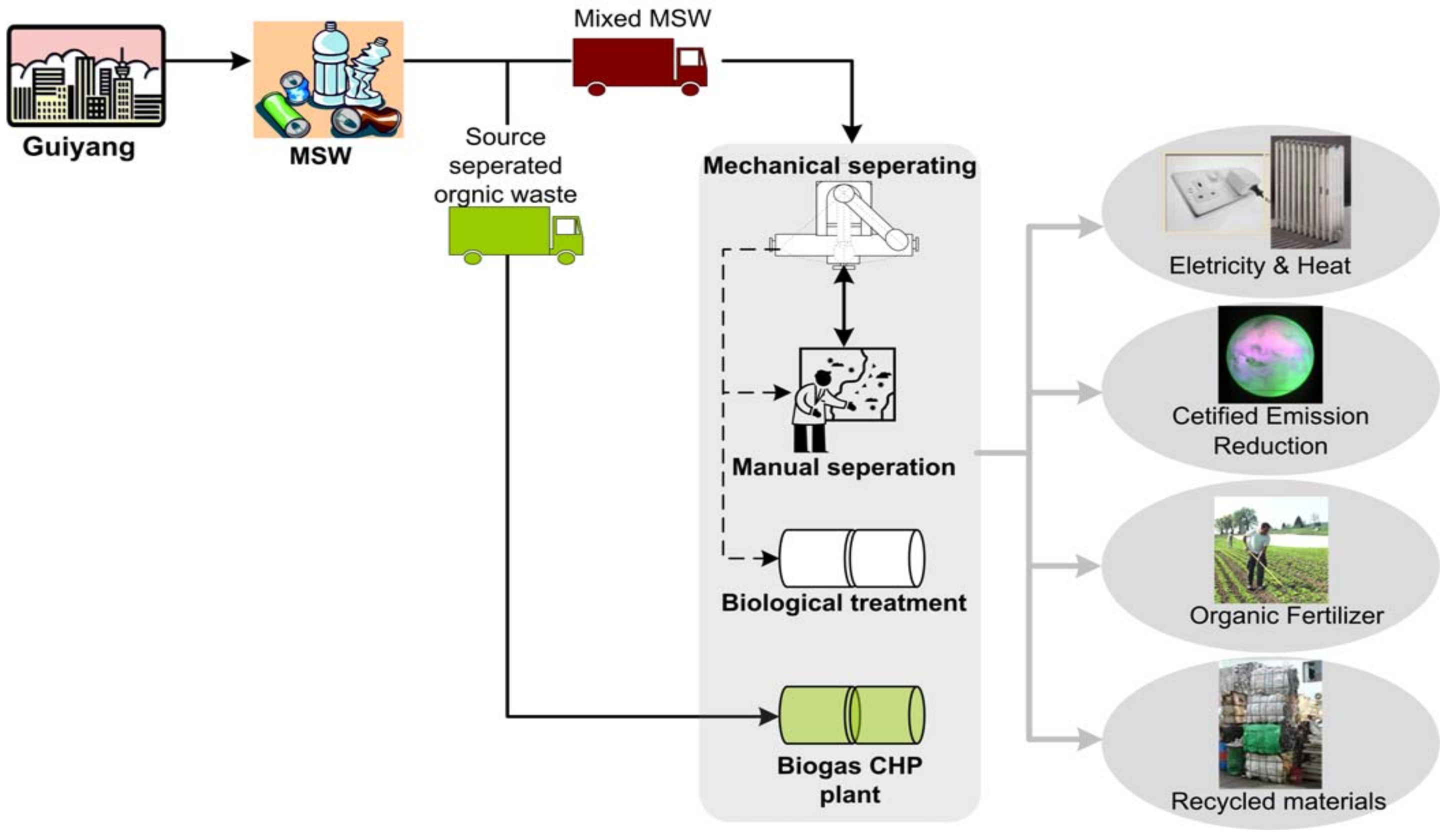
Visions of this project: Turning wastes into resources



Increasing Regional Added Value

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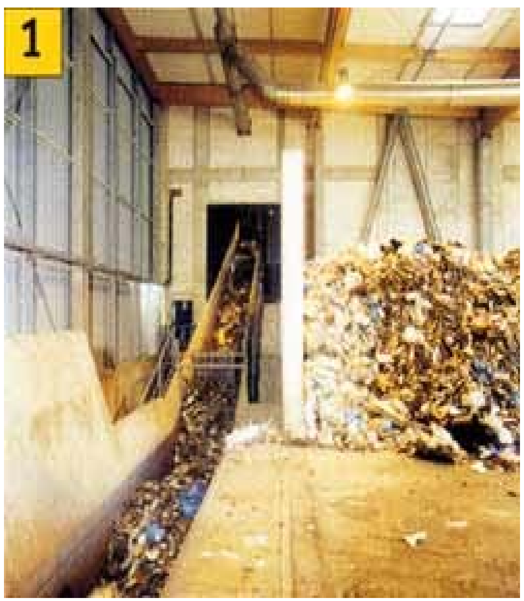
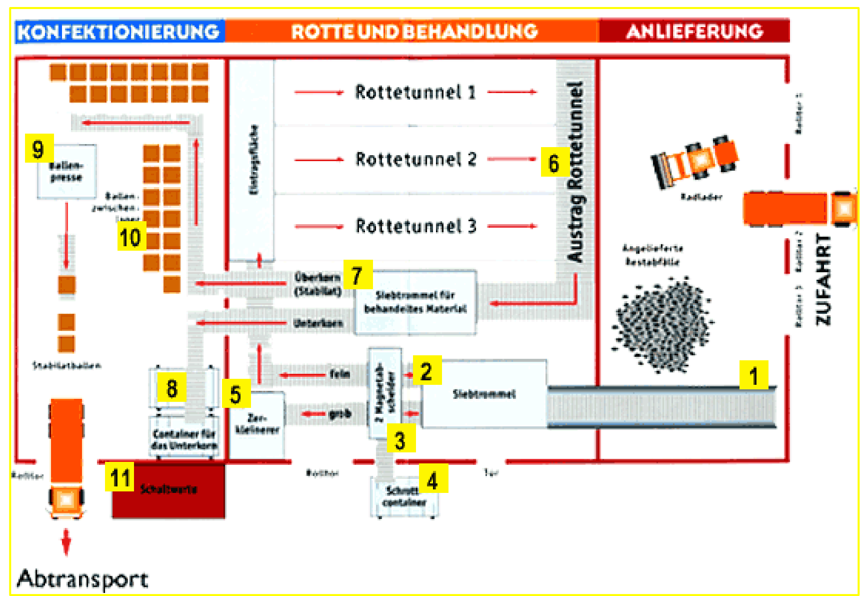
Mechanical-biological treatment

- Separation of high calorific value waste
- Aerobic or anaerobic treatment of organic waste
- Landfilling of treatment residues





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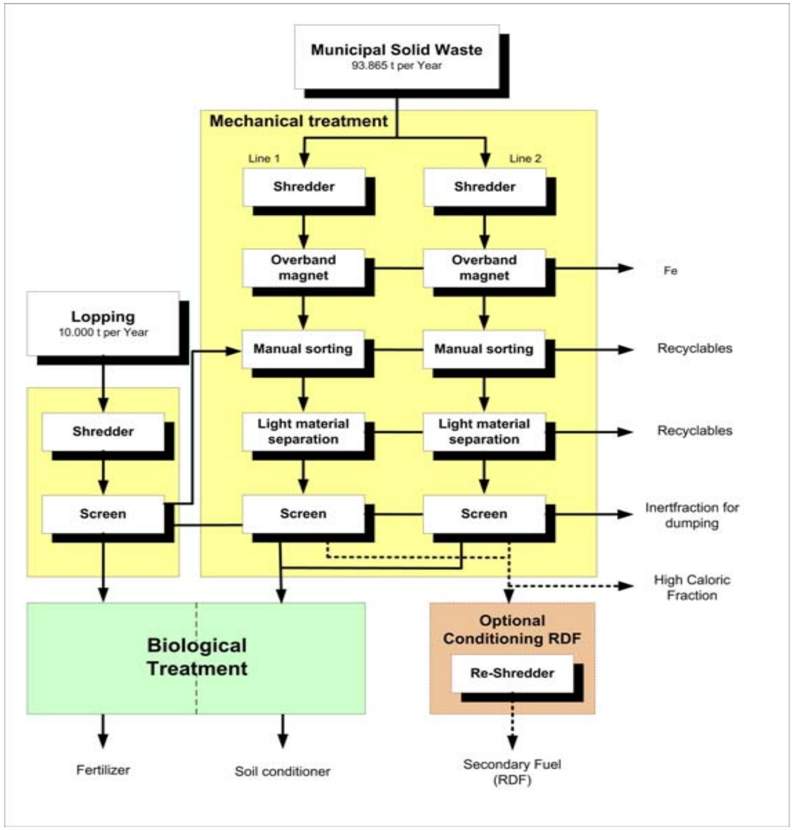
Basic Concept – Mechanical Treatment

- Separation of the organic fraction & recyclables



Rudnick & Enners
Maschinen- und Anlagenbau GmbH

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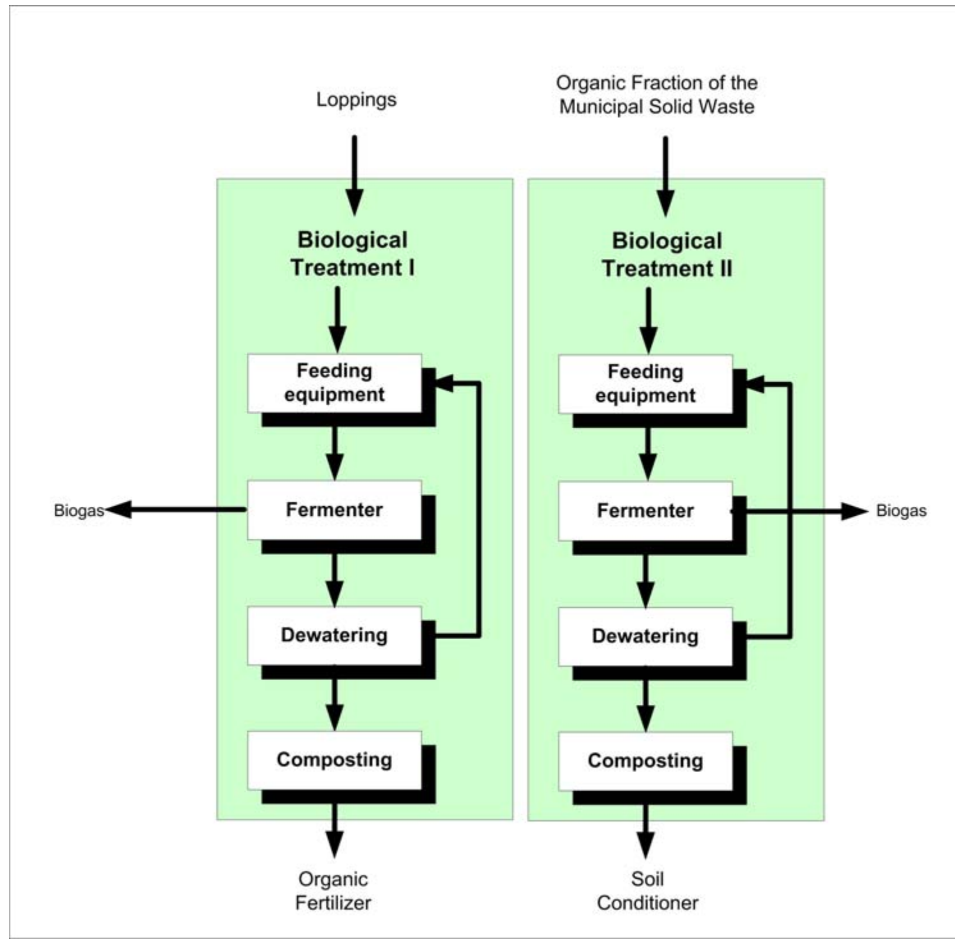
Basic Concept – Biological Treatment

- Stabilisation, production of fertilizer & soil conditioner

KOMPOGAS
Grüngutverwertung mit Energiegewinnung



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Biological treatment for uncontaminated organic fractions

50 liters of oil and 600 kg fertilzer or waste?

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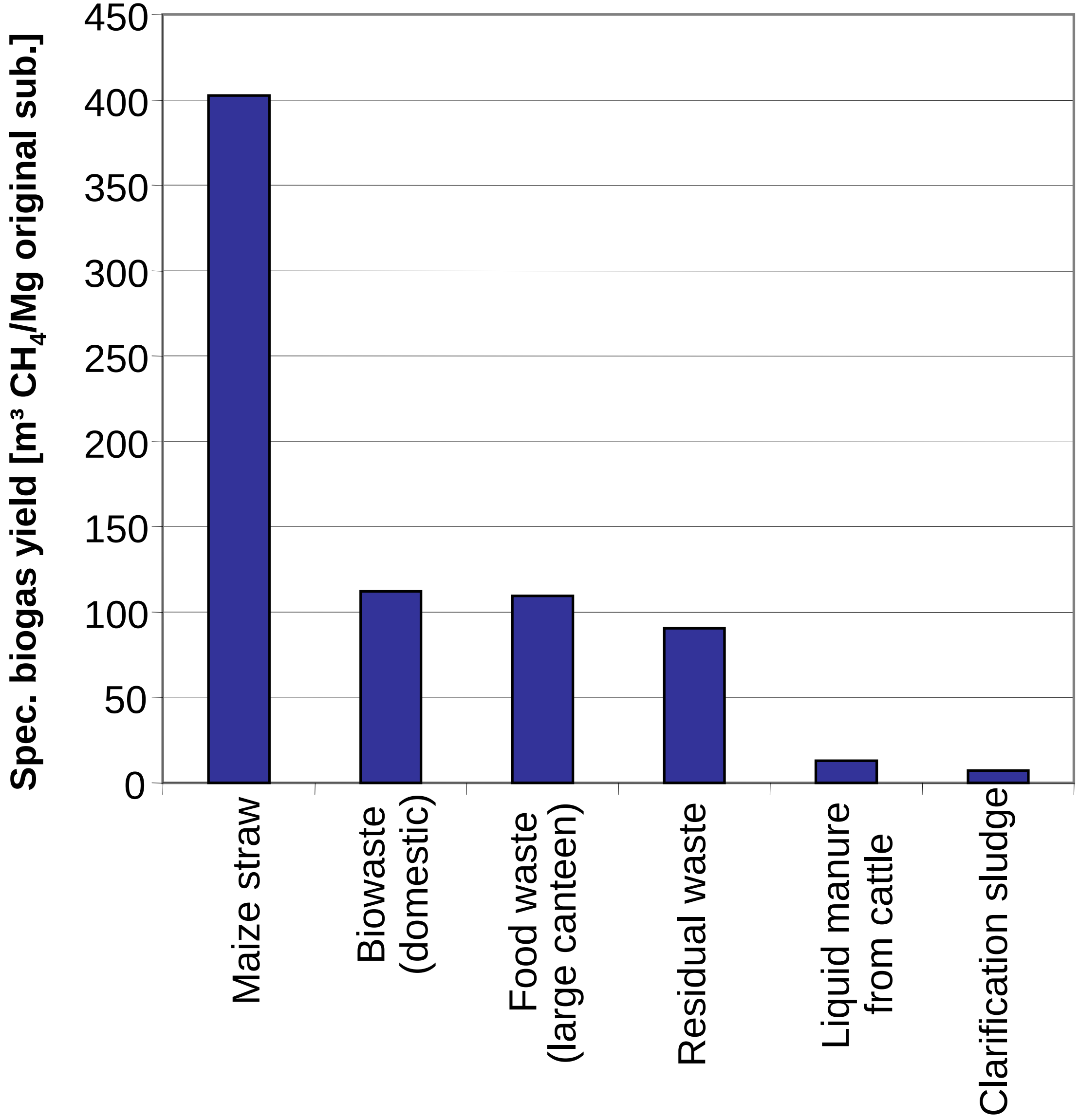
Specific Biogas yield (2)



Liquid and solid fertilzer

solid

liquid

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Energy content of organic waste

- Organic material can be used fermenter where different kinds of bacteria are degrading organic matter to methane gas
- 1 t of organic waste contains +/- 100 m^3 of biogas
- Methane content/m^3 biogas = 55-60% = 6 kWh
- 1 t of organic waste contains +/- 600 kWh

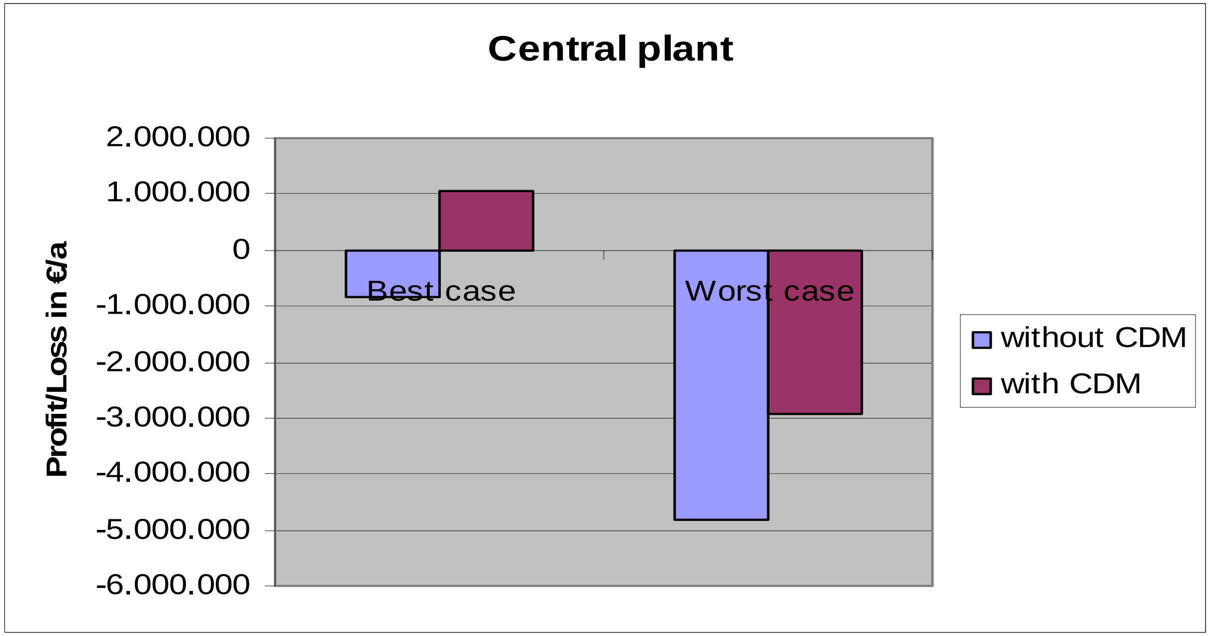
Energy content of waste in Antalya (Turkey)

- Total amount of waste: approx: 400.000 t
- 240.000 t of organic waste
- 160.000 t of non organic waste

- at least 12.000.000 m^3 methan (= 12 Mio liter oil)
- = 120 Mio KWh energy (46 Mio Kwh electricity, 46 Mio KWh heat)
- RDF 80.000 t = 24 Mio liter of oilequivalent (300 liter per ton)
- 200.000 to 400.000 t of CO_2 avoided

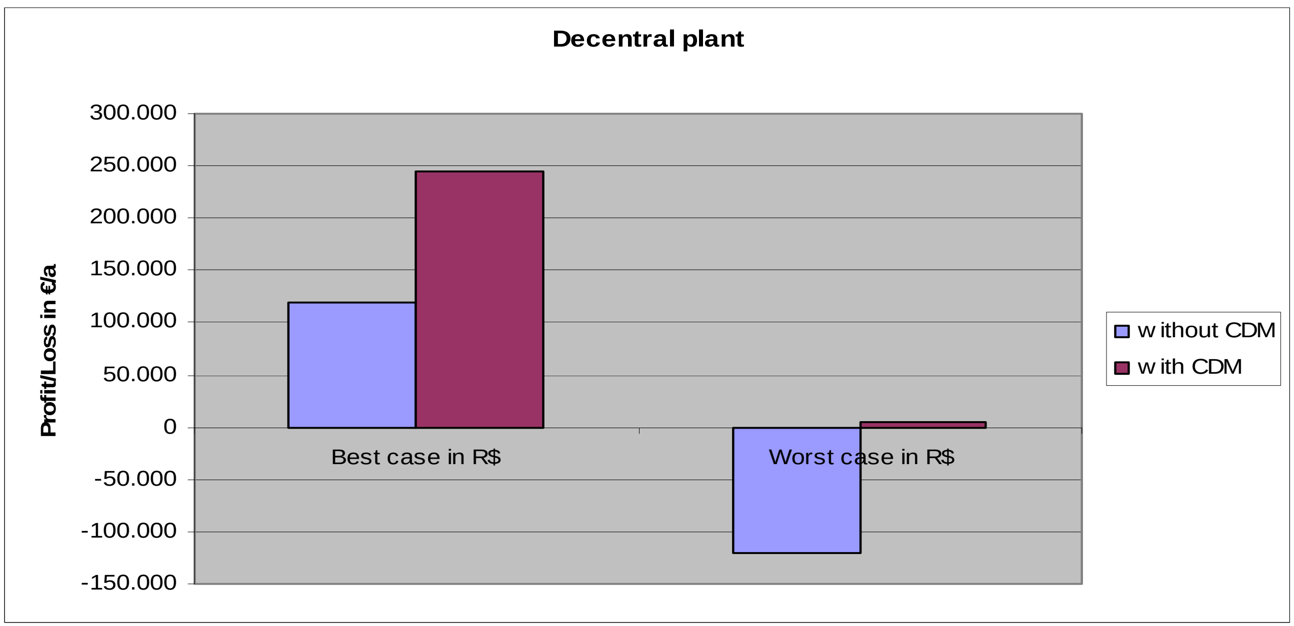
Calculation central plant

	R$	R$	€	€
	Best case	Worst case	Best case	Worst case
Benefit / Loss (without CDM-selling)	-2.166.703	-12.519.240	-942.045	-5.443.148
Return on Invest (in %)	-1,0	-5,7	-1,0	-5,7
Cash Flow	8.846.634	-1.505.903	3.846.362	-654.740
Benefit / Loss (with CDM-selling)	2.752.000	-7.600.536	1.196.522	-3.304.581
Return on Invest (in %)	1,2	-3,5	1,2	-3,5
Cash Flow	13.765.337	3.412.800	5.984.929	1.483.826

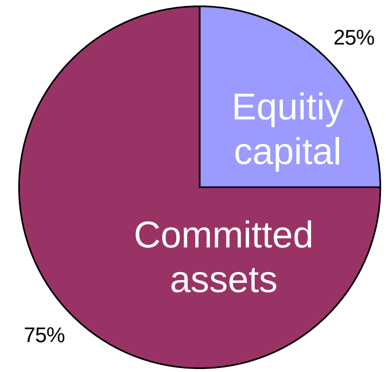


Calculation decentral plant

	Best case in R$	Worst case in R$	Best case in €	Worst case in €
Benefit / Loss (without CDM-selling)	273.739	-279.079	119.017	-121.339
Return on Invest (in %)	2,3	-2,4	2,3	-2,4
Cash Flow	861.842	309.025	374.714	134.359
Benefit / Loss (with CDM-selling)	563.539	10.721	245.017	4.661
Return on Invest (in %)	4,8	0,1	4,8	0,1
Cash Flow	1.151.642	598.825	500.714	260.359



Funding concept for capital building



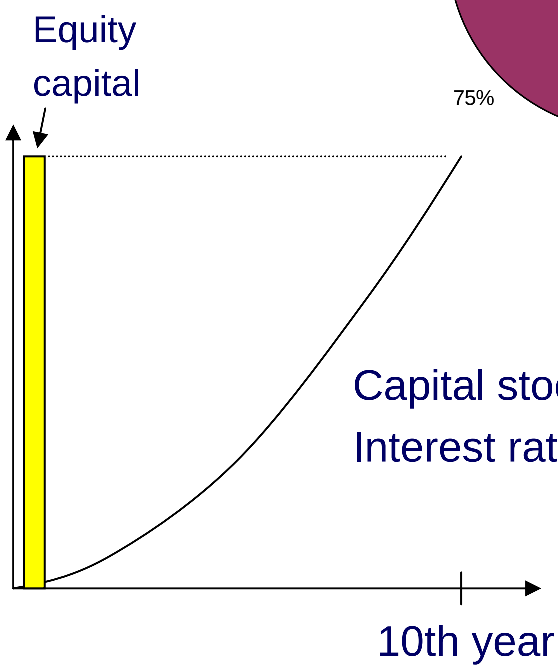
Monthly payment for waste collectors

Salary

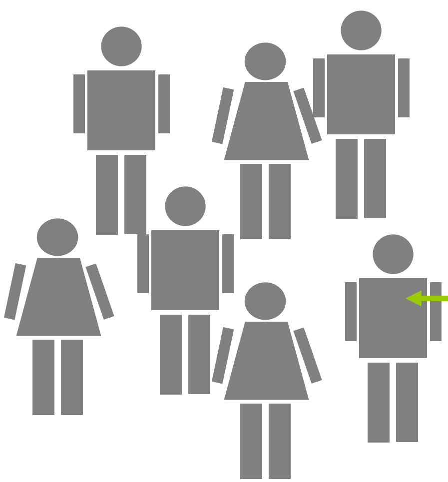
Payed monthly to worker

Share for fund

monthly inserted for every worker



Capital stock in fund;
Interest rate: 2,5%



Transfer of equity capital to workers

Buy out of international investors

Comparison between composting and fermentation

	Composting plant middle size		Biogas plant middle size	
	Electricty (kWh_{el}/ton)	Heat (kWh_{th}/ton)	Electricty (kWh_{el}/ton)	Heat (kWh_{th}/ton)
Energy demand				
Mechanical and biological needs	55	0	50	100
Energy generation				
from biogas cogeneration unit	0	0	200	400
Energy balance	**-55**	**0**	**150**	**300**

(Source: Dach et al. 2007)


RZ

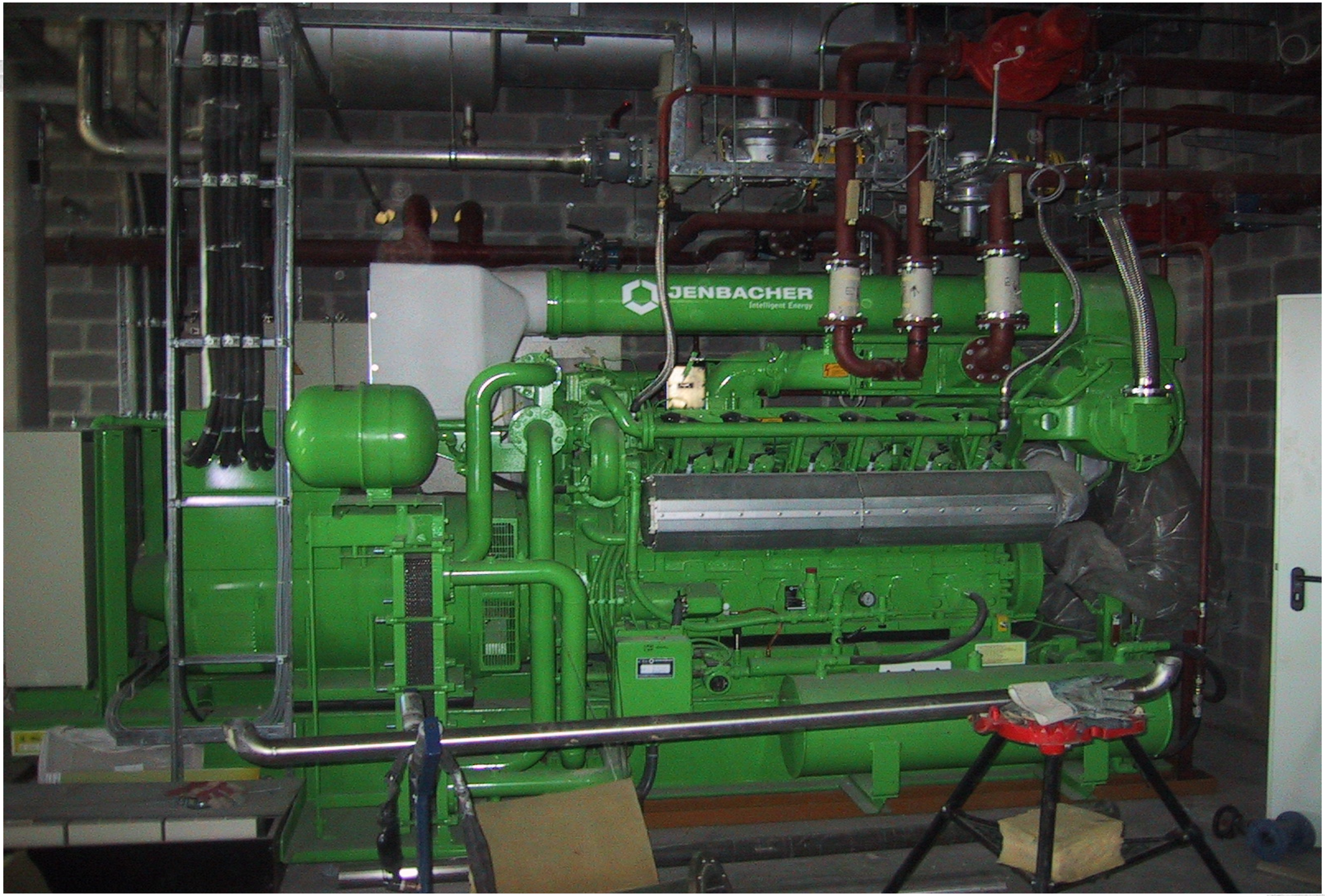
Example: a Biogas CHP Plant in Donau-Wald Region, Germany

Designed capacity
Input (biowaste): 39,000 ton/year
Biogas output :4,480,000 Nm3/year
Electricity output: 9,100,000 KWh/year

Operation: from 2004.11
(source: KOMPOGAS)

Biogas from municipal waste as a fuel in Malmö, Sweden

Cogeneration Unit



Hall sportif raccordé au réseau

Piscine communale raccordée au réseau

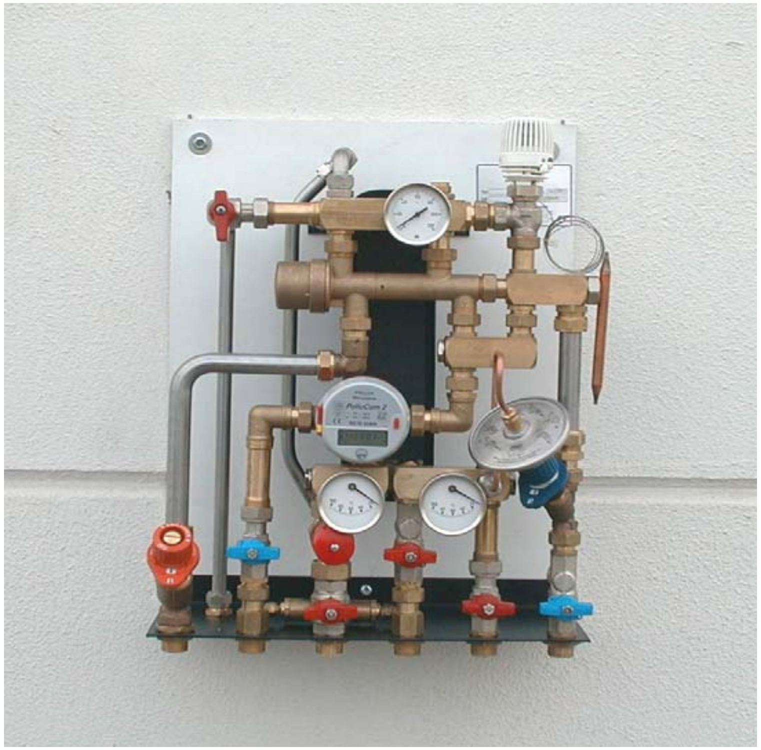
Atelier communal raccordé au réseau

Installation de biométhanisation

Site prévu pour un centre scolaire avec hall sportif et piscine (réalisation en 2004)

Site de la raffinerie d'herbe (projet)

District heating or district cooling with excess heat from cogeneration



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How are the fertilizer products used?

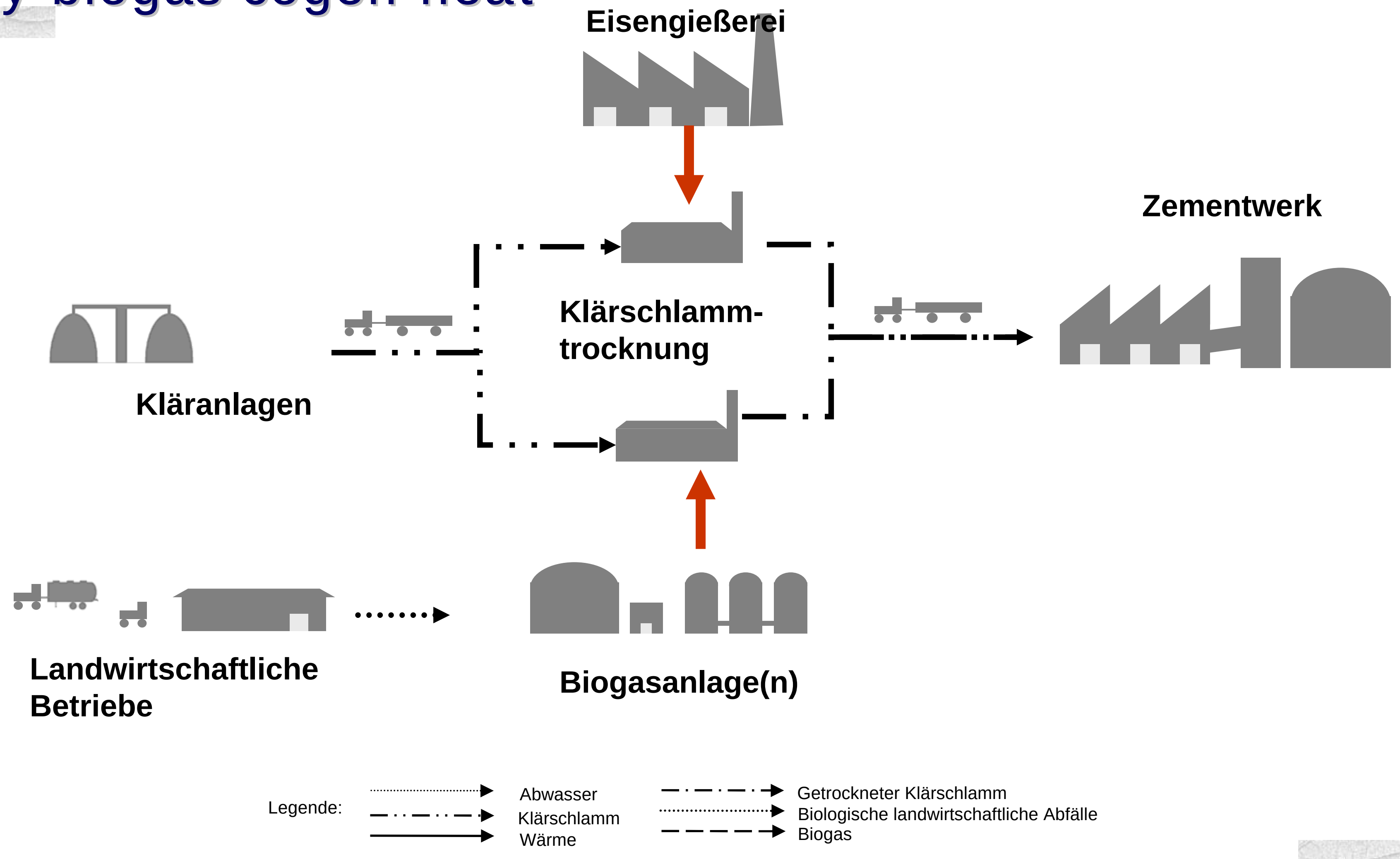
Liquid Fertilizer

Solid fertilizer

Energy need for fertilizer production

- To produce 1 kg of nitrogen fertilizer on fossil base most efficient plants use 0,75 kg of natural gas or propane gas as energy and hydrogen source with an equivalent of approx 0,8 to 2 litres mineral oil.
- One litre of fossil fuel produces 2,6 kg of CO_2-emissions
- One ton of nitrogen in the organic fertilizer reduces therefore 2,6 t CO_2
- In 1000 t of organic fertilizer there are 8 t of Nitrogen
- The organic fertilizer to be produced reduces fossil energy and resource use. Reduction of 4.900 t of CO_2

Example for Regional Material Flow Management (RMFM): Use of sludge in cement factory after drying by biogas cogen heat



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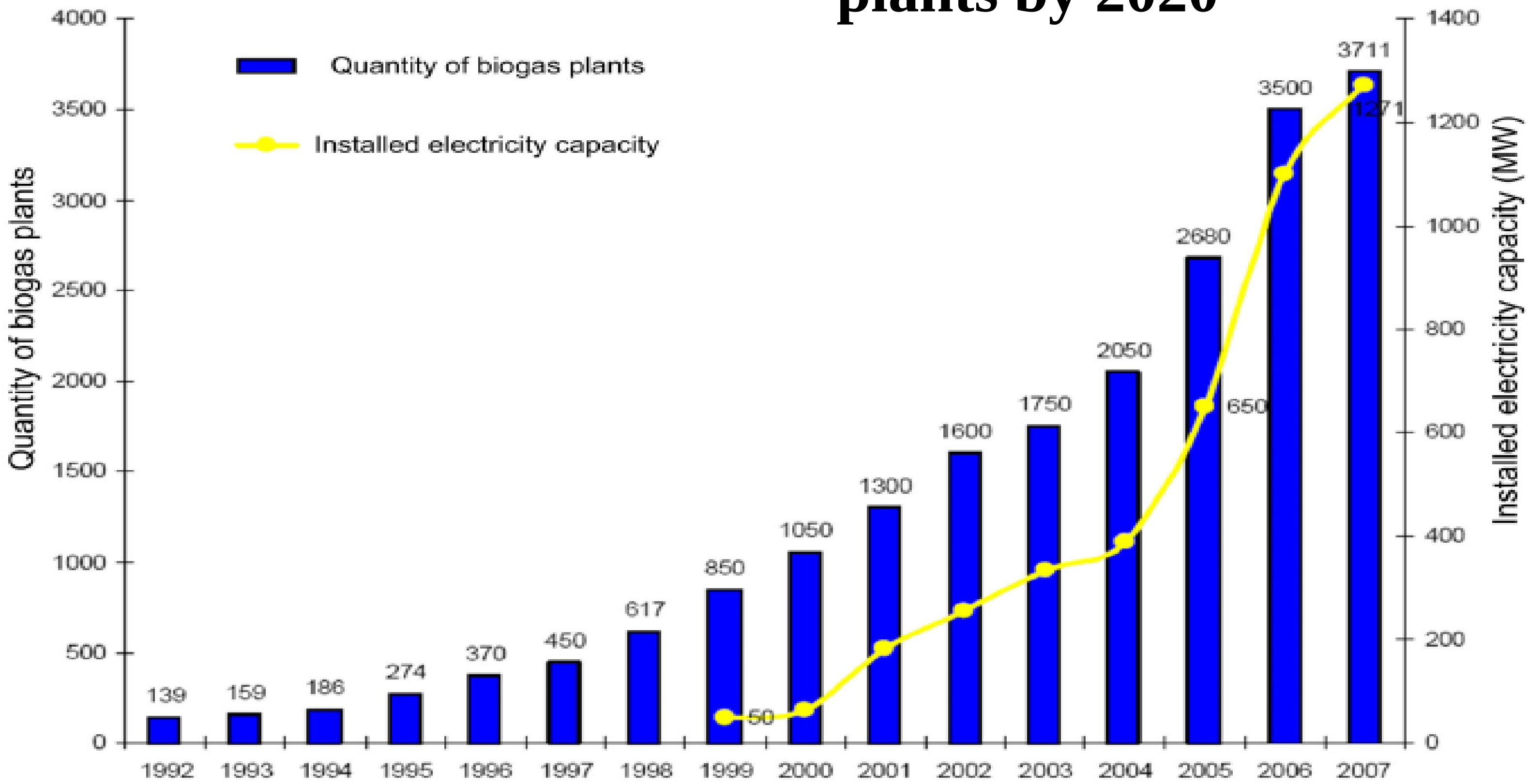
Biogas plants in Germany

Target 10.000 biogas plants by 2020



(Source: GBA, 2007)

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Utilisation of light fraction for RDF-Production

- Resource derived fuel can be produced from organic material, paper, wood, plastic, rubber, textiles to create a high caloric fuel that can be used e.g. in cement industries

RDF pellets

RDF utilisation in cement industry

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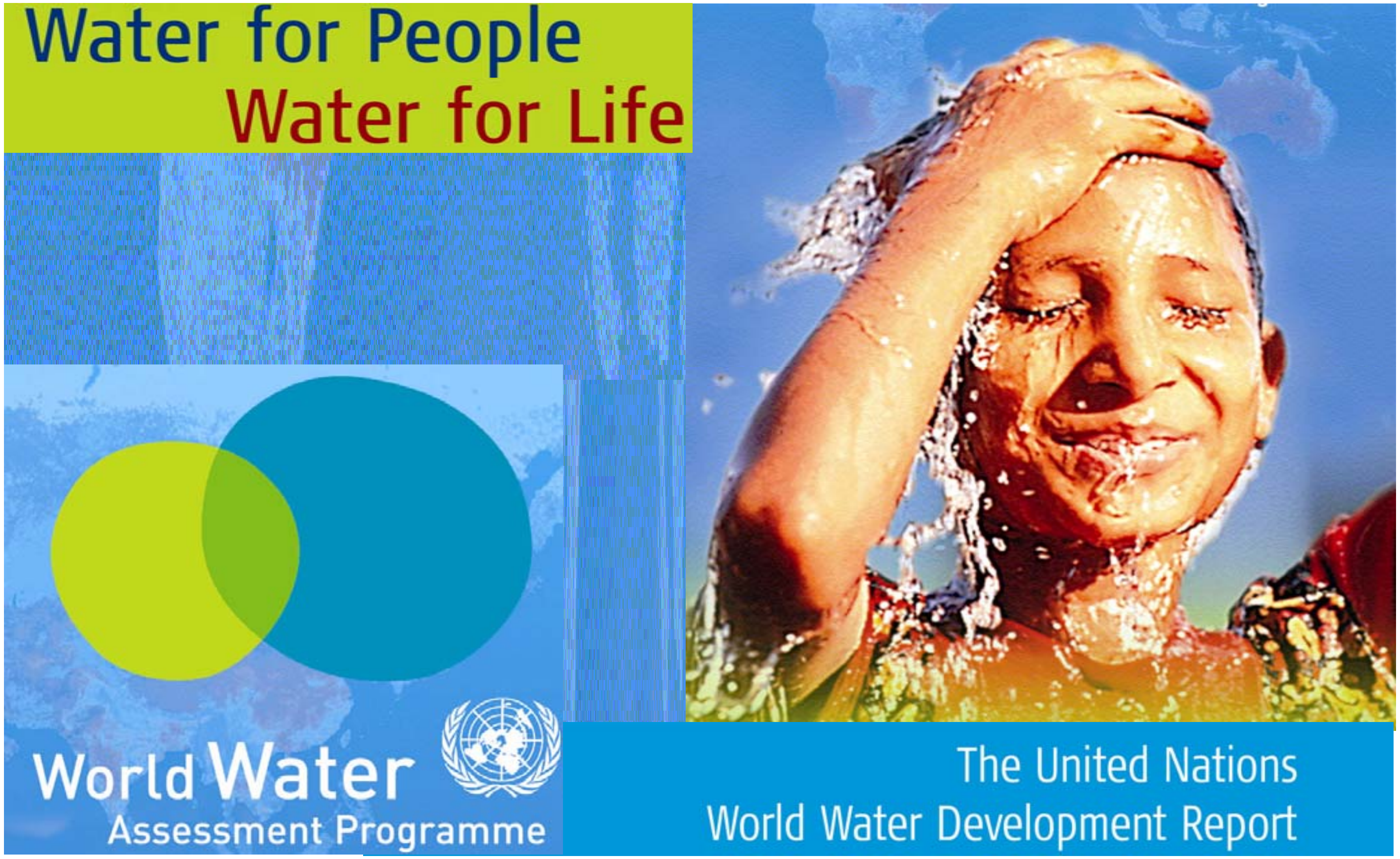
Sustainable Water Management?



“Definition” & historical background

Sustainable wastewater treatment means

- To manage the “Material flow” of waste water contents
- To treat wastewater with low energy budget

You can implement swt in different ways: natural systems, decentralized systems, separation systems, classical systems with modern technology,…

“Definition” & historical background

The classical comprehension of waste water leads to the following “technical solutions”:

- Collecting waste water in sewers
- To treat the wastewater in centralized treatment plants

➔ Out of sight, out of mind

What means "to collect wastewater in sewers" and treat it in centralized plants?

Germany collects and transports wastewater within a network of 486.000 km* sewer.

→ Not sustainable, not transferable to most countries

(albeit a good quality of water bodies is reached in most rivers and lakes)

Facts and Figures

… we pay a stiff price for the water quality when treating wastewater in centralized treatment plants:

- Drinking water is used as the medium for waste-transportation
- Technical plants → approx. 0.5 kWh / cbm wastewater
- Most TP are working with activated sludge → large amount of sludge
- Centralized treatment plant → mix of low and high polluted waste water and also a lot of pollutants in the sludge; at last sludge is burnt, and for example phosphorus too
- Nitrogen is denitrified, primary as N_2, but also as N_xO_x, e.g. N_2O
- cleaned water is not reused

Energy from waste water

Childrens playground and ...

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Prof. Dr. Peter Heck

rain water collection and..

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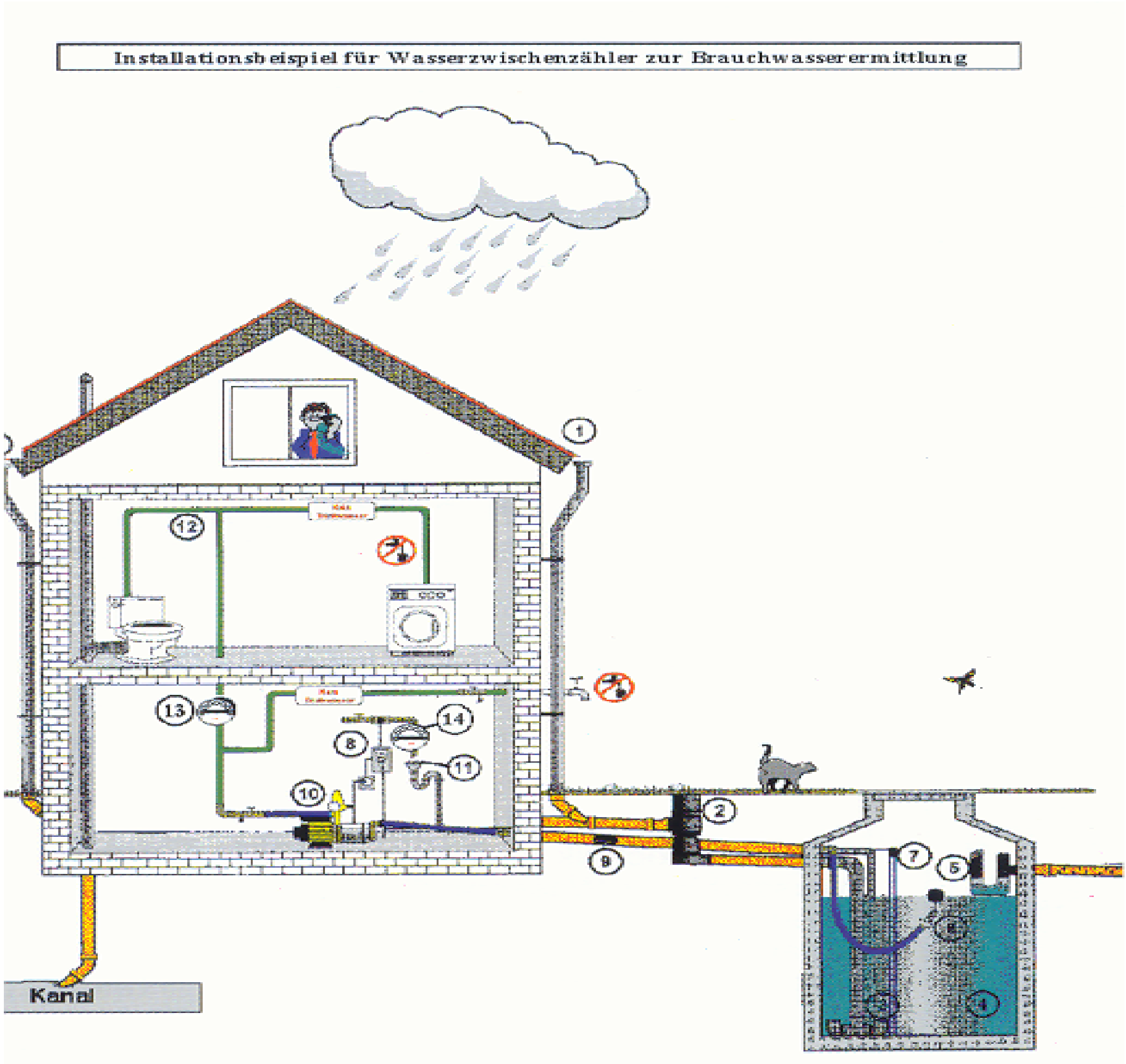
rain water reuse and..



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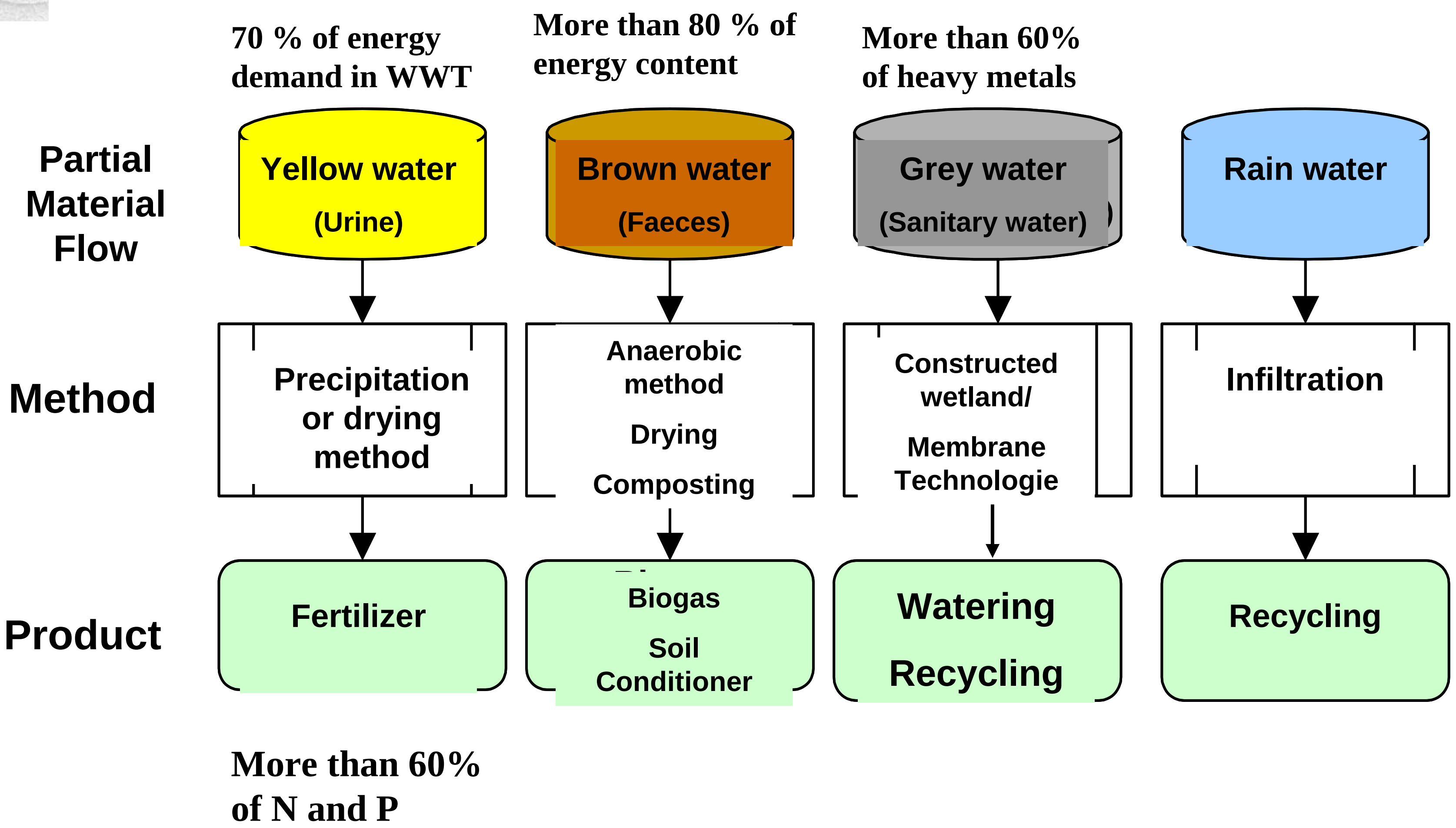
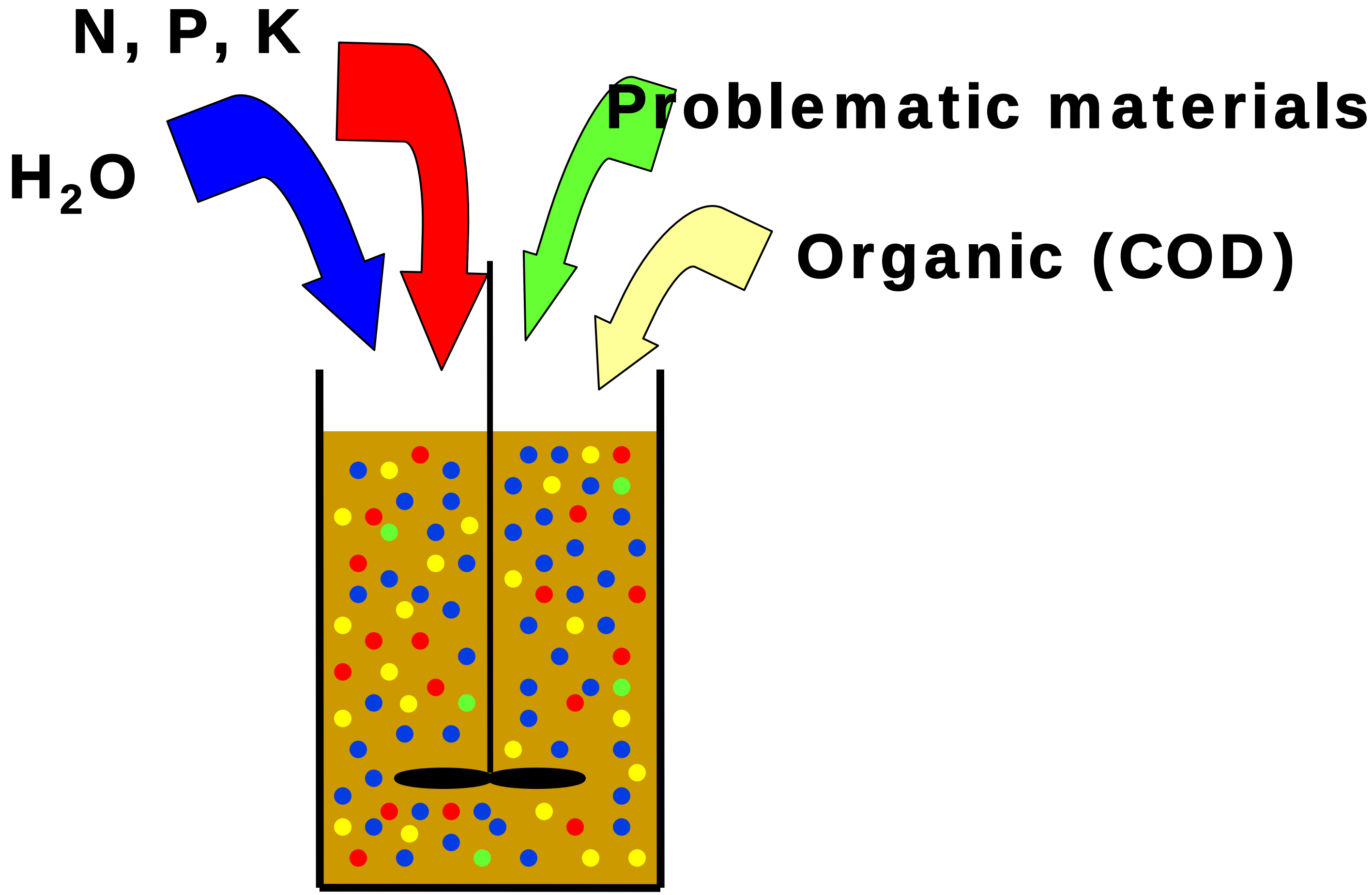
rain water biotops

Separation of waste water in material flows:



Waste water – a cocktail of nutrients and energy



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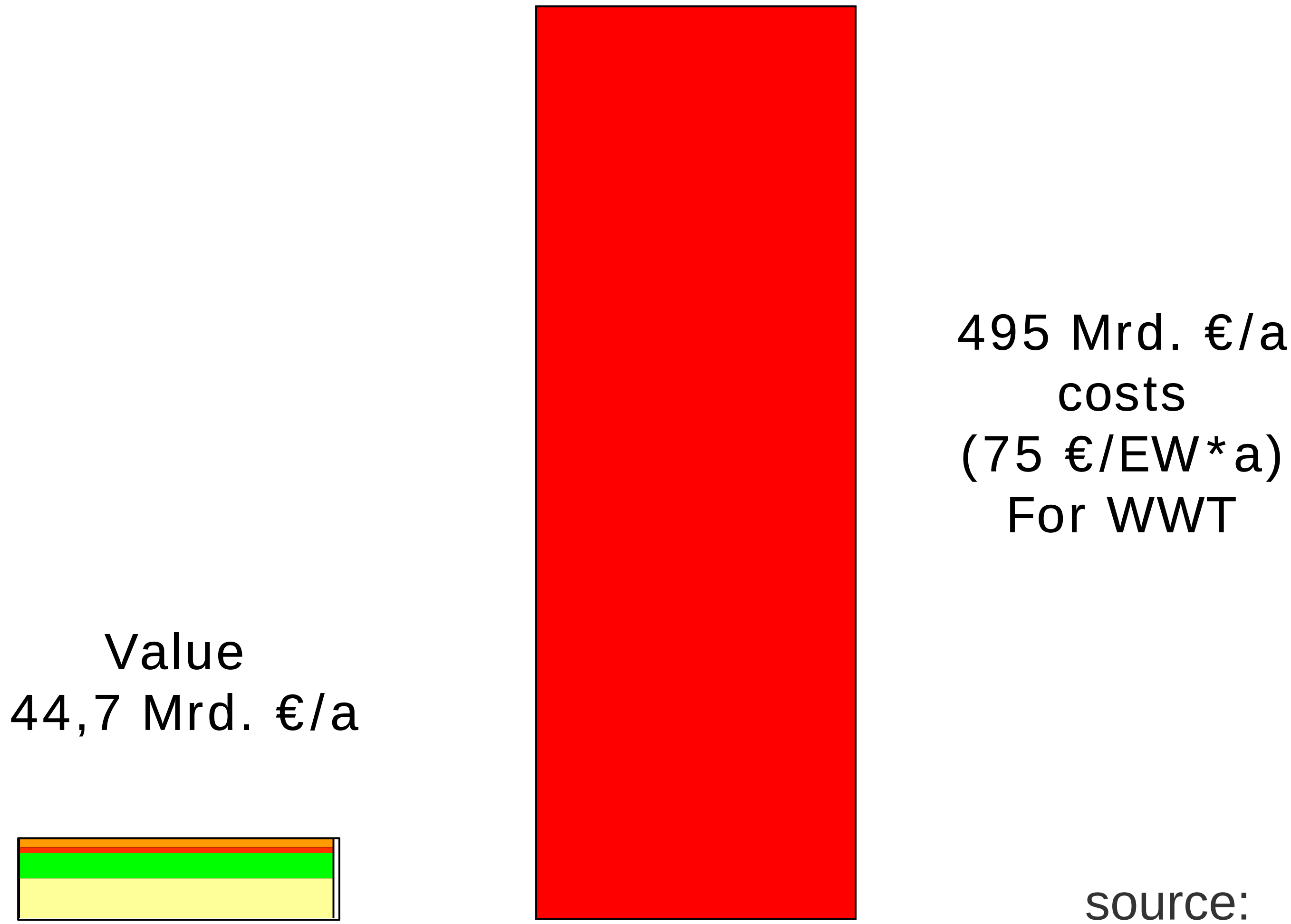
Economic value

Resource	value
(P)	0,78 €/kg P
(N)	1,02 €/kg N
(K)	0,38 €/kg K
Org. Stoffe (CSB)	0,08 €/kg CSB

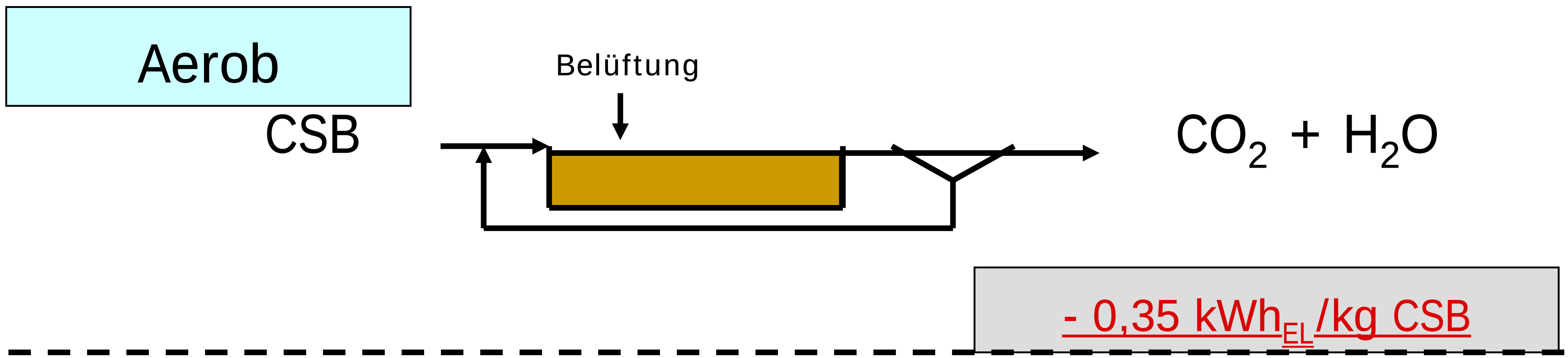
source: Dockhorn

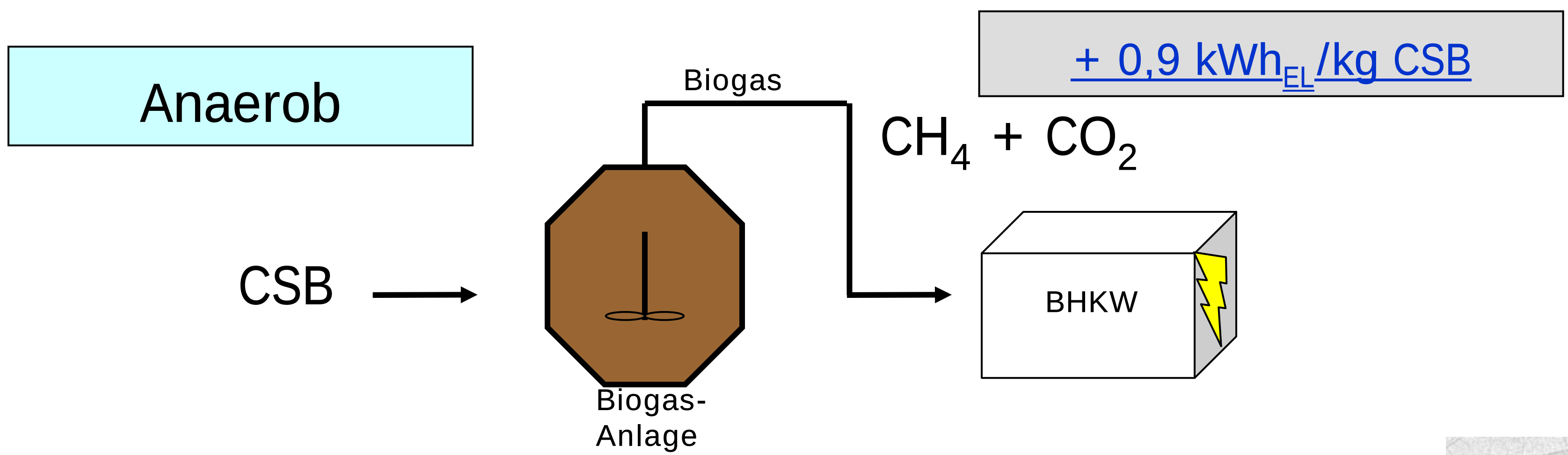
Value of resources from waste water and what we pay for not using it!



source: Dockhorn

Aerob gegen Anaerob





Disposal or reuse?

Constructed Wetland (HuaXin/Shanghai)




CSP – Huge Potential in Northern Africa

- less than 4% of the Sahara area is sufficient to cover world electricity demand
- An area of 600km x 600km would provide enough electricity for the world
- the boxes indicate the necessary space to cover the electricity demand of the world, the EU-25, Germany

Jatropha plantation in Cairo, Egypt

Surface irrigation with waste water

Jatropha nuts: Fuel production from the desert with waste water

3000 Liter of fuel and 50 m^3 CH_4 per ha

First yield after 8 months

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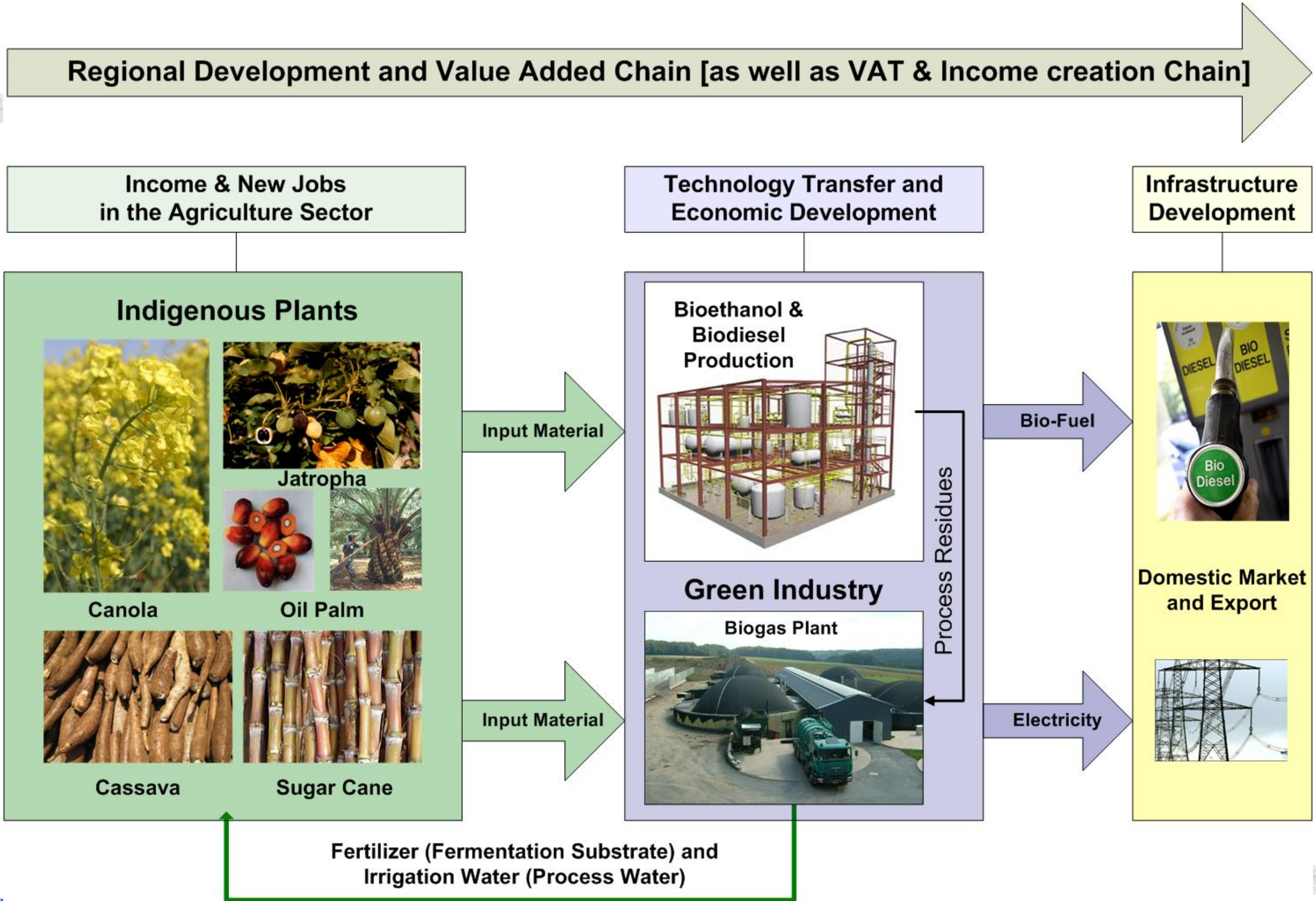
Local potential and local added value



Session Case studies

Circular Economy Project in Fuzhou Luxia (China PRC):

Biomass potentials for Circular Economy

(Luxia town turning pollution into bio-energy and fertilizer project)

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Luxia county

Lage von Luxia in der Provinz Fujian

population 12.915 area: 91km²

Actual situation I

Animal dung is partly used as fertilizer but the majority is untreated discharged into the nearby river.

Actual situation II

The uncontrolled discharge of the livestock residues create problems in drinking water supply and energy generation [the water hyacinth block the hydro power plant].

Vision for Luxia

Change the waste flow to a resource flow by a Material Flow Management Master Plan for Circular Economy

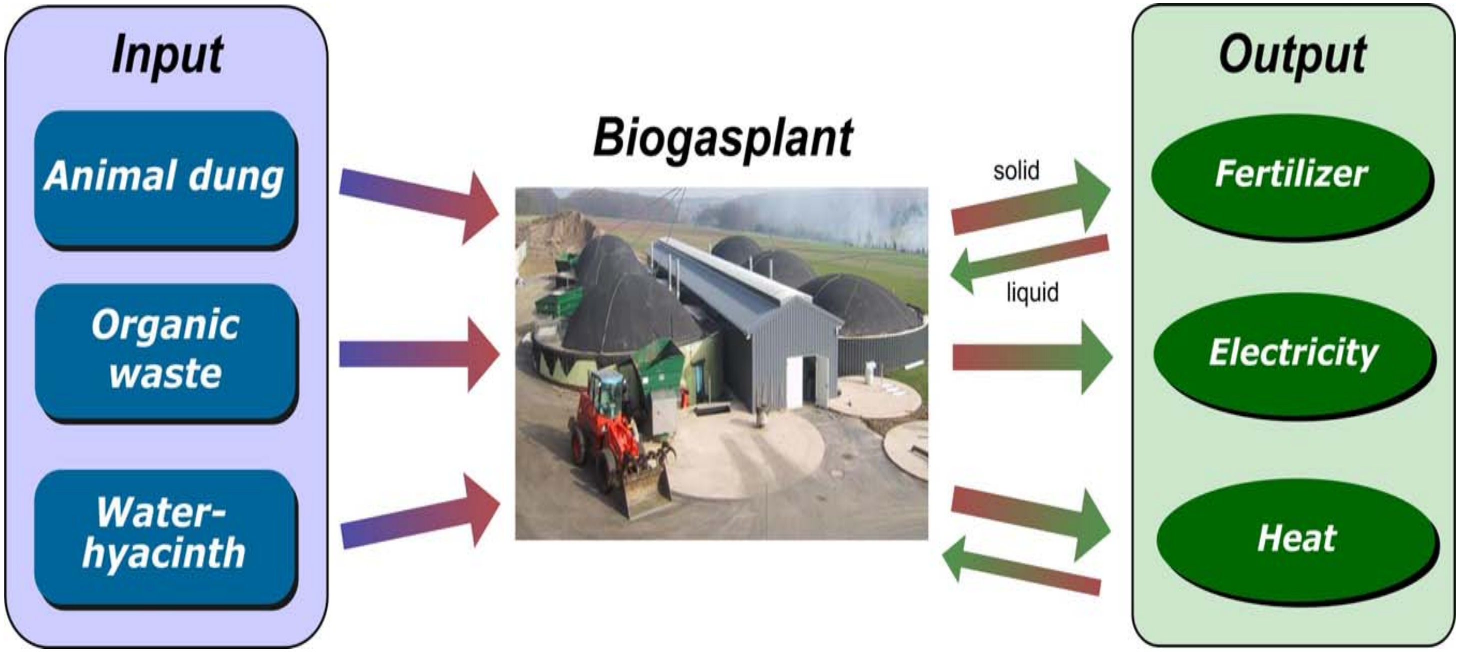
→ better conditions for drinking water supply

→ energy generation (electricity and heat)

→ bio energy and organic fertilizer technology as a core pillar to advance the Fujian Strait Western Bank Economic Zone Strategy

→ creation of new jobs

Future situation



System: Collecting the pig manure of selected farms with pipes on strategic points to produce Biogas and organic-fertilizer.

Unused Biomass Potentials

- Pig manure (50.000 of 150. 000 pigs)

  10.000 t organic residues (e.g. market waste or livestock industry waste)

  1.000 t waterhyacinth
- 3,5 Millions m^3 Biogas

  => 6.740 MWh electricity
  9.000 MWh heat
  } 1,9 Millions Litre Oil-equivalent
- 2 Millions m^3 Methane (CH_4)
- Green House Gas potential of 28.100 tons CO_2-equivalent

Zero-Emission-Village Weilerbach

Study and implementation of CO_2 neutral village of 24.000 inhabitants

ZEV

Weilerbach

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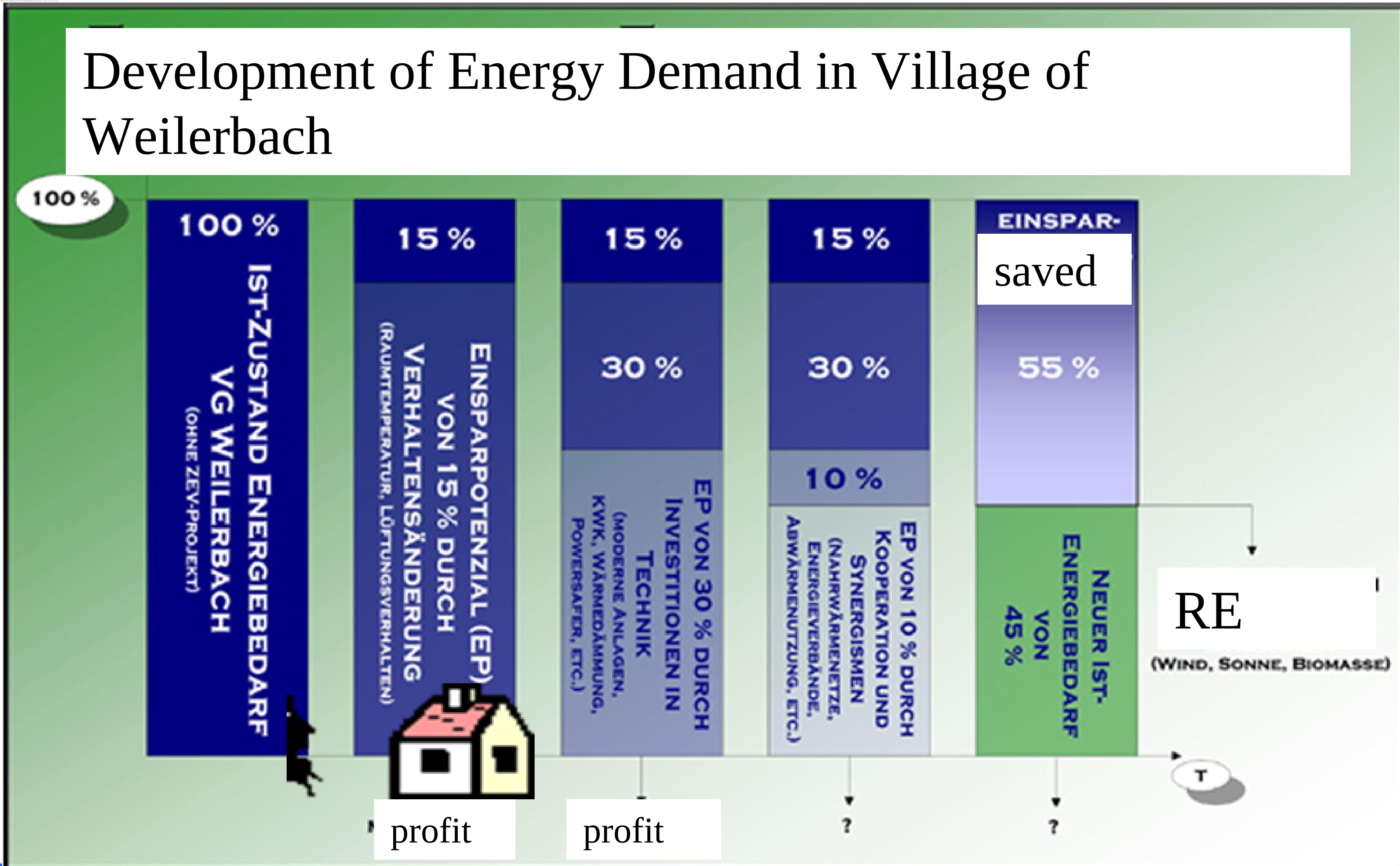
Implementation of ZEV



Bioenergy Village Grimburg: location biogas plant

500 KWpel

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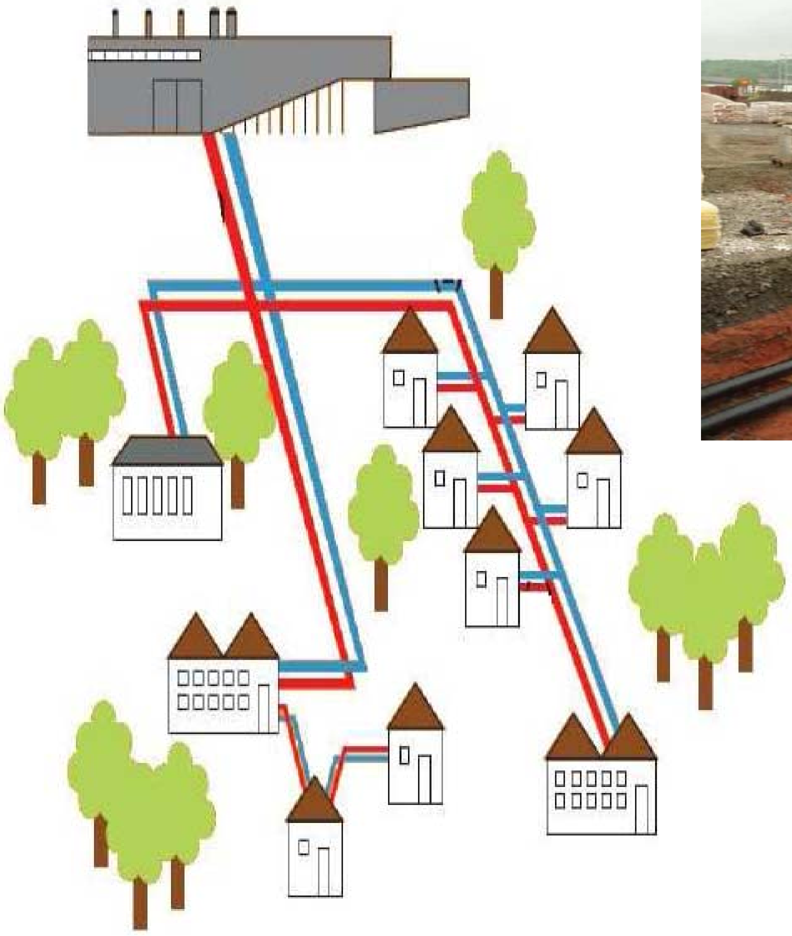
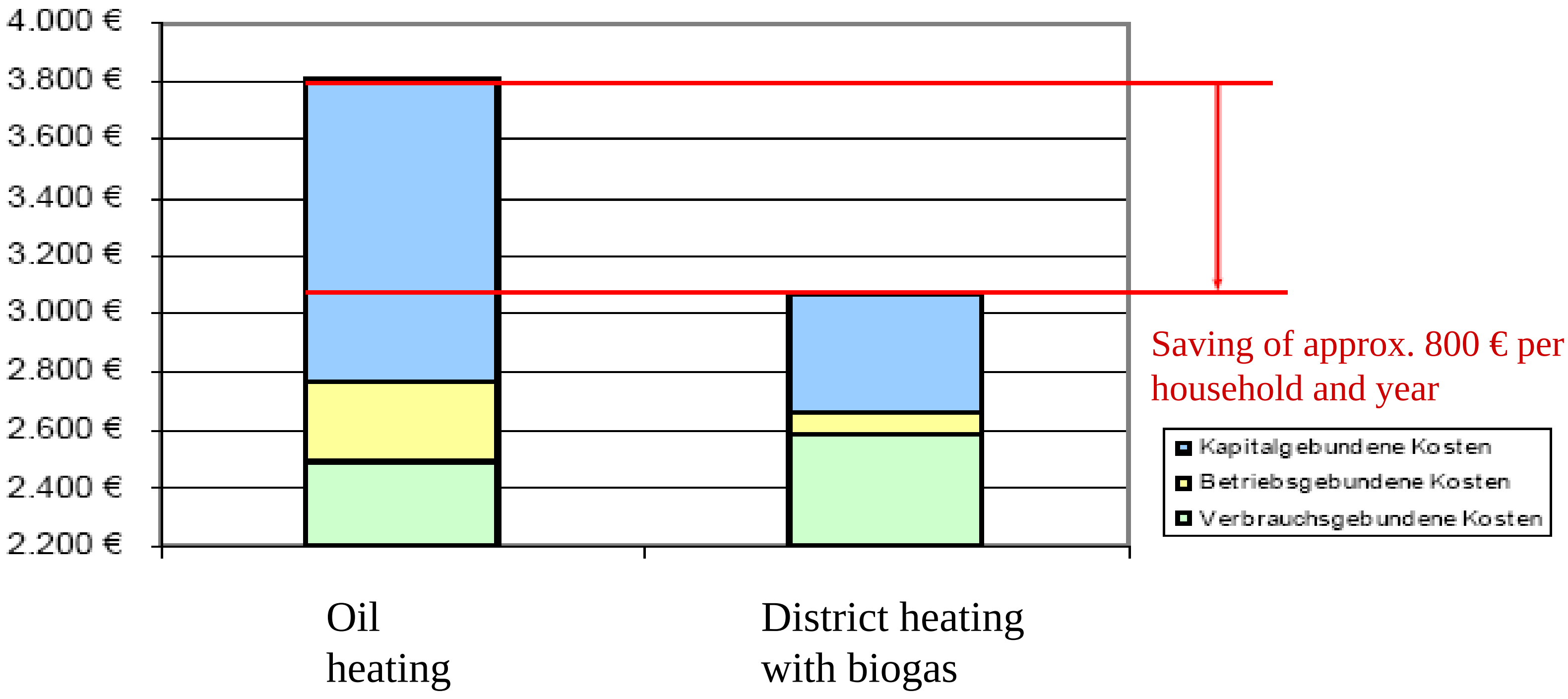
Nahwärmenetze



Money saving per household through biogas heat or cold



ZEV: Scenario electricity

Ist-Situation	Verbrauch Strom (MWh)		Erzeugung CO2 (Mg CO2 / a)		
Jahr 1999	42.300		26.811		
Soll-Szenario	Erzeugung Strom (MWh)	Investitions-kosten (€)	Eingespartes CO2 (Mg CO2 / a)	Eingespartes CO2 (20 Jahre) (Mg CO2 / 20 a)	Invest pro Mg eingespartes CO2 (€ / Mg CO2) **
Windkraft (6x2 MW)	23.000	16.800.000,00 €	14.597	291.933	57,55 €
PV (5 MW)	4.200	25.000.000,00 €	2.665	53.310	468,96 €
BHKW (1,5 MW)	12.000	1.500.000,00 €	7.616	152.313	9,85 €
Einsparung 10 % ***	4.200	12.600.000,00 €	2.665	53.310	236,36 €
Gesamt:	43.400	55.900.000,00 €	27.543	550.865	101,48 €
Überschuß*:	1.100		-732		

angenommene Laufzeit für alle Maßnahmen: 20 Jahre

* Durch die vollständige Nutzung der vorhandenen Biomassen können zusätzlich bis zu 5.000 MWh Strom erzeugt werden

** Investitionskosten (€) / Mg CO2 in 20 Jahren

*** Annahme: nur Durchführung von Maßnahmen mit max. Kosten pro eingesparte kWh von 0,145 €

ZEV: Scenario heat

Ist-Situation	Verbrauch Wärme (MWh)	
Jahr 1999	105.000	
Soll-Szenario	Erzeugung Wärme (MWh)	Investitions-kosten (€)
Biomasse	34.300	
davon Altfett	12.000	s. Strom
davon Holz	5.600	800.000,00 €
sonstige*	16.700	n.n.
ST (8000 m2)	3.200	25.000.000,00 €
Wärmepumpen**	24.400	3.660.000,00 €
Einsparung 40 % ***	42.000	84.000.000,00 €
Gesamt:	**103.900**	113.460.000,00 €
Überschuß	-1.100	

angenommene Laufzeit für alle Maßnahmen: 20 Jahre

* Kurzfristig verfügbare Potenziale ohne techn. Konzept

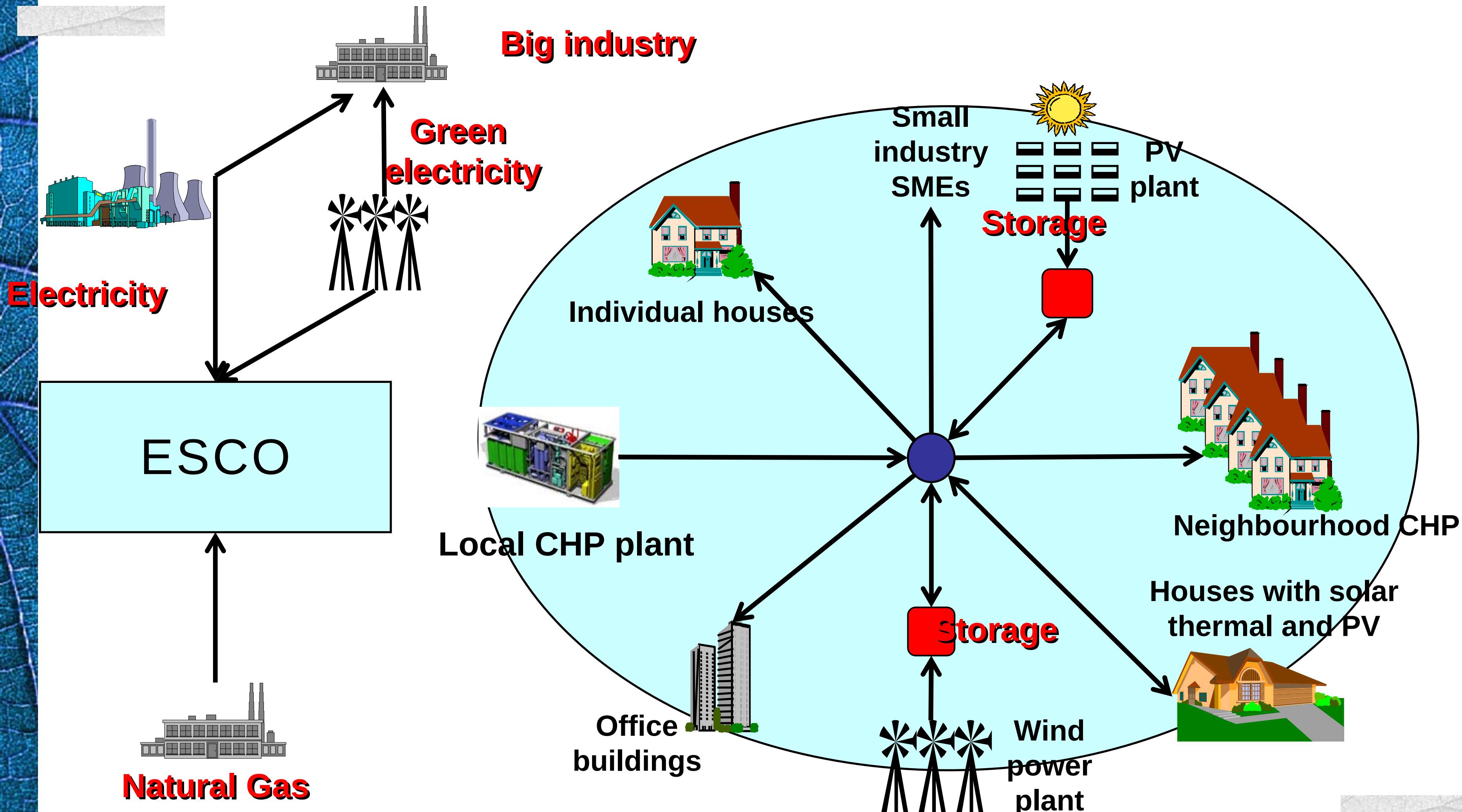
** Der zum Betrieb der Wärmepumpen benötigte Strom wird durch den Überschuß aus der Stromproduktion gedeckt

*** Annahme: nur Maßnahmen mit max. Kosten pro eingesparte kWh (in 20 Jahren) von 0,10 €

Investment after two years

Wind turbines (10 MW, ~ 19.000 MWh/Jahr)	~ 13.900.000 €
Photovoltaic (~ 5.000 m², 450.000 kWh/Jahr)	~ 2.500.000 €
Solar Thermal (~ 1.200 m², 570.000 kWh/Jahr)	~ 1.440.000 €
District heating Palmenkreuz (~ 150 Bauplätze, HHS-HZ/Erdgas)	1.300.000 €
District heating Reichenbacher-Weg (~ 240 Bauplätze, HHS-HZ/Erdgas) ~	1.700.000 €
District heating Sennsmannswiese (18 Bauplätze, HHS-HZ)	~ 170.000 €
Insulation of schools	~ 500.000 €
Total	**~ 21.510.000 €**

EU Commission research program CONCERTO "Zero Emission Community"



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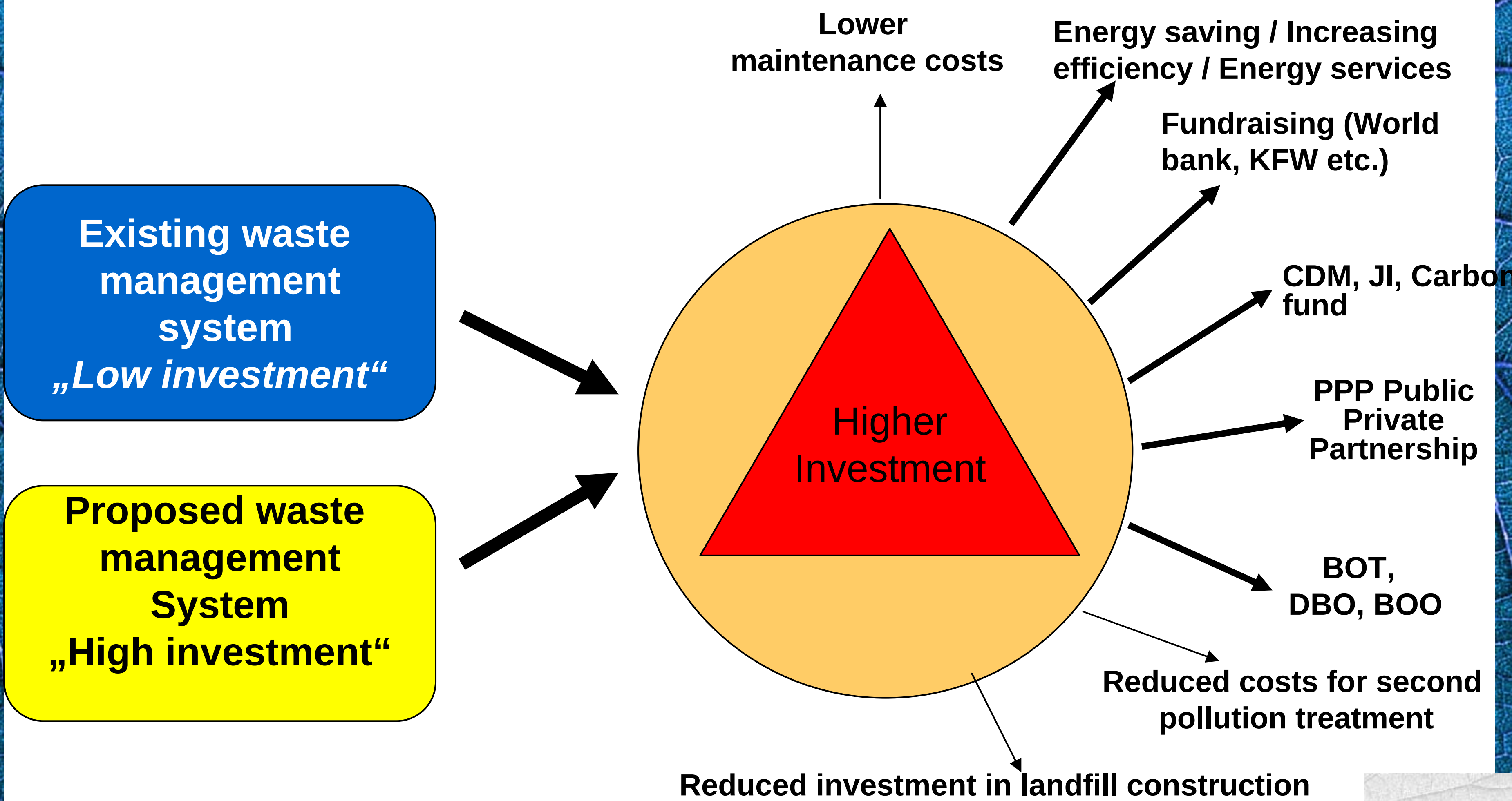
Financing with carbon dioxide trading (Kioto protocol)

Potential Contributions to Project Cash Flow

Technology	Δ IRR %
Energy Eff.-District Heating	2.0
Wind	0.9-1.3
Hydro	1.2-2.6
Bagasse	0.5-3.5
Biomass with methane kick	**Up to 5.0**
Municipal Solid Waste with methane kick	**>5.0**

Source: Prototype Carbon Fund (World Bank), 2001 (preliminary data)

How can a „sustainable waste management“ system be financed?



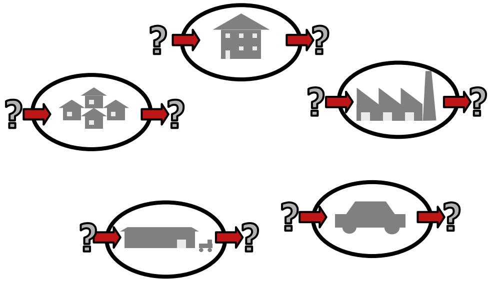
*„A clever man **solves** problems,*

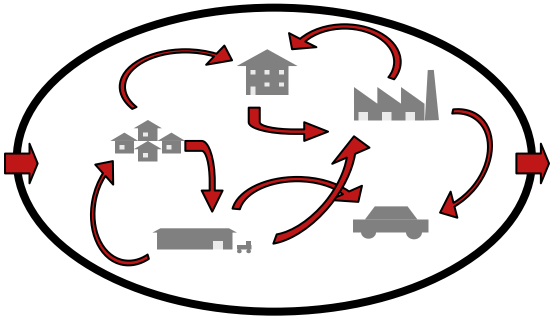
*a wise man **avoids** them“*

(*Chinese proverb*)

Discover the Secret....

Thank you for your time and attention





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